An Investigation of Skeletons from Type-R Settlements along the Riet and Orange Rivers, South Africa, Using Stable Isotope Analysis

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Dissertation presented for the degree of Masters of Science in the Department of Archaeology

University of Cape Town

February 2015

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Plagiarism Declaration

I know the meaning of plagiarism and declare that all of the work in this dissertation, save for that which is properly acknowledged, is my own.

Abstract

In the last centuries before incorporation into the Cape Colony, the Riet and Orange River areas of the Northern Cape, South Africa were inhabited by communities of hunter-gatherers and herders whose life ways are little understood. These people were primarily of Khoesan descent, but their large stone-built stock pens attest to the presence of substantial herds of livestock, very likely for trade. This region was too dry for agriculture, although we know that there were links with Tswana-speaking agricultural communities to the north, because of the presence of characteristic styles of copper artefacts in Riet River graves. This was a frontier region at a turbulent time in South African history, so one of the questions about these societies is the extent to which they were homogeneous or heterogeneous –were many outsiders incorporated into these communities? What was the relative importance of herding compared with hunting in the local economy? Did connections with farming communities extend to the trading of cereal foods? These issues are explored through measuring $\delta^{13}C$ and $\delta^{15}N$ of bone collagen, and $\delta^{13}C$ and $\delta^{18}O$ of tooth enamel based on the principle that the isotopic values of consumers are similar to those of the food they eat. The $\delta^{13}C$ results suggest that people who occupied the area exploited both C_3 and C_4-based foodstuffs in varying proportions.Most of the individuals analysed have fairly similar bone chemistry, indicating that they consumed isotopically similar mixes of foods for much of their lives, although there are a few outlying individuals whose life histories should be investigated further. A plot of $\delta^{13}C_{(collagen)}$ against $\delta^{13}C_{(enamel)}$ from the same individual indicates a very weak correlation between the two variables($R^2 = 0.21$), probably because different sources of dietary carbon are differentially incorporated into bone and tooth enamel. Although the archaeological data from which this study draws is limited, its use with stable isotope chemistry permits the contribution of knowledge to the history of South Africa's prehistoric interior.

To my parents

Acknowledgements

I would like to sincerely thank my supervisor, Professor Judith Sealy, whose guidance and dedication has been my motivation to finish this thesis. I thank the South African Research Chairs Initiative and the National Research Foundation for their financial support. I thank Professor Tim Maggs for his assistance and advice in the project. My appreciation and thanks to Dr David Morris (McGregor Museum, Kimberley) and Mr Brendon Billings (School of Anatomical Sciences, Wits) for arranging and allowing me access to the physical anthropological collections. I thank Mr Ian Newton and Mr John Lanham for their assistance with analysing my samples. To Dr Ashley Coutu and Ms Sally Adams, I thank them for assisting me with my maps. I thank Ms Julie Luyt and Ms Simone Brunton for their encouragement. Lastly, I thank my parents and sisters for their encouragement and support.

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Chapter One:

Introduction

This study investigates the life ways of a group of individuals who inhabited the area alongside the Riet and Orange River areas in the centuries prior to the incorporation of this region into what was to become the Cape Colony. Light stable carbon and nitrogen isotope analysis of the bone and tooth enamel of each individual is employed to find out more about the diets they consumed during life. This should help us to understand the economy of their society, and to make comparisons with other, better-researched communities in the region.

The study area is located between Plooysburg in the Northern Cape and Jacobsdal in the southwestern Free State (Fig. 1.1). This was a frontier region during an unstable time in South African history, so the questions addressed are: What was the extent of outsider incorporation into these communities? What was the relative importance of herding versus hunting and gathering within the local economy? Did trading relations with agricultural communities extend to the trading of cereal foods? Lastly, with the knowledge that tooth enamel preserves better than bone, this study also attempts to elucidate the relationship between stable carbon isotope ratios of bone collagen and tooth enamel. That is, in the absence of collagen, can analyses of enamel still be used to answer archaeological questions?

These communities, who were of Khoesan descent, built settlements that included large stone circles used as livestock pens, a phenomenon typically associated with Bantu-speaking Iron Age farming communities. Domesticated livestock were kept, probably mostly for trading purposes. As will become evident in the chapters to follow, the Riet River area is a dry area that is not suitable for agriculture. The presence of exotic grave goods such as cowries and other sea shells, glass beads and metal artefacts in the Riet River graves indicates active participation in long-range trading networks. Certain styles of copper artefacts, in particular, demonstrate a link with Tswana-speaking farming communities to the north.

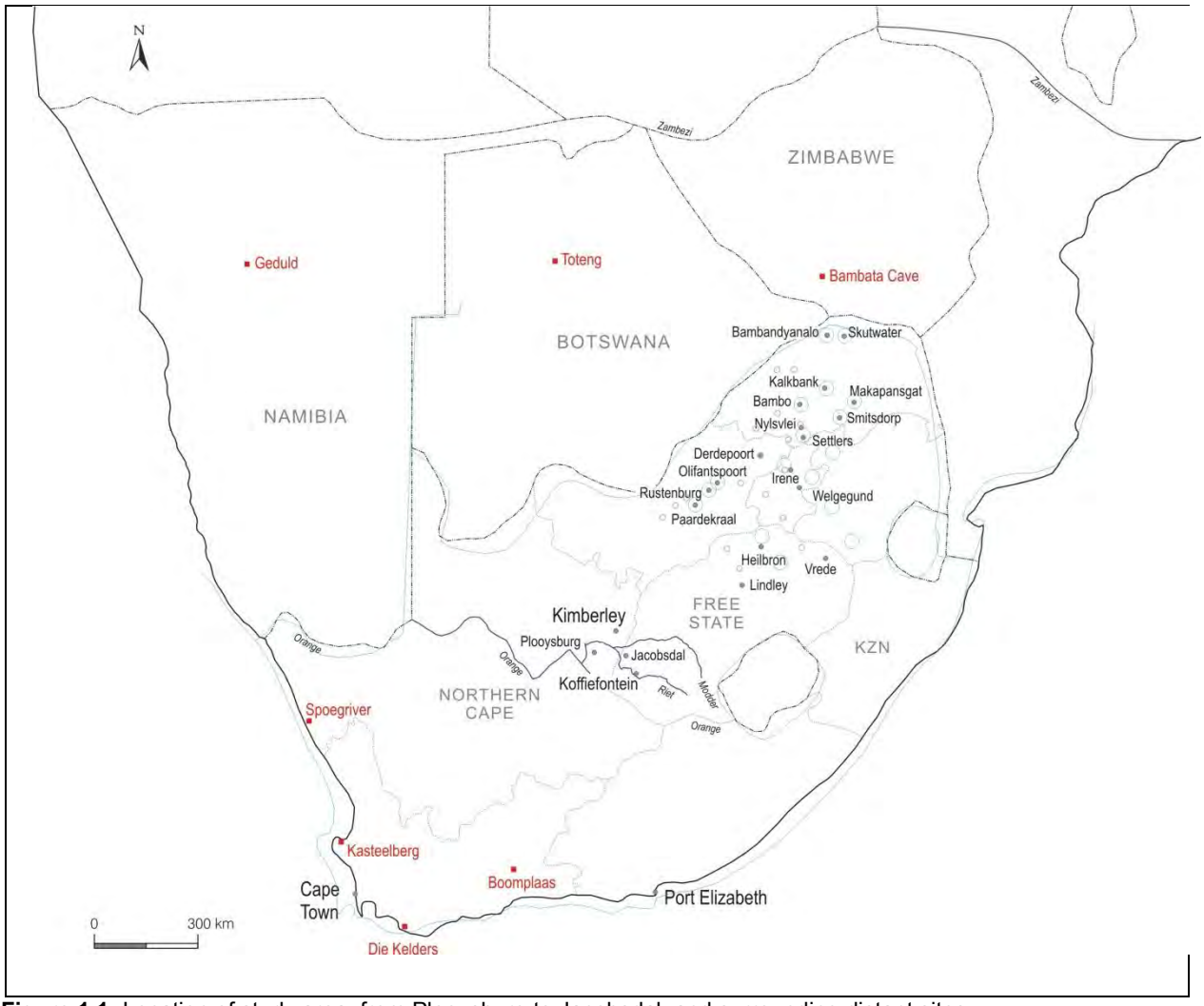

Figure 1.1: Location of study area, from Plooysburg to Jacobsdal, and surrounding distant sites.

The majority of the Riet River burials were excavated between 1922 and 1946 by a keen amateur archaeologist, W Fowler (Humphreys 1970). Fowler avidly collected both skeletons and grave goods, which he donated to various museums in South Africa. Fifty eight of the skeletons are kept at the McGregor Museum, Kimberley (Morris 1992). Other institutions that house some of the skeletons include the University of the Witwatersrand Anatomy Department, and the National Museum in Bloemfontein (Morris 1992). In the late 1920s and early 1930s, Van Riet Lowe reported on his observations of the settlements and graves from the site of Afvallingskop, near Koffiefontein (1929; 1931). In the mid-1960s, du Toit (1964) worked on additional graves from Driekops Eiland. It wasn't until the late 1960s and early 1970s that Maggs (1967; 1971) worked in the area and its settlements that they were termed the Type R Settlement Complex. These were so named because of their location along the Riet River. A typical Type R

settlement unit consists of a single large primary enclosure with a few smaller enclosures around it (Fig. 1.2).

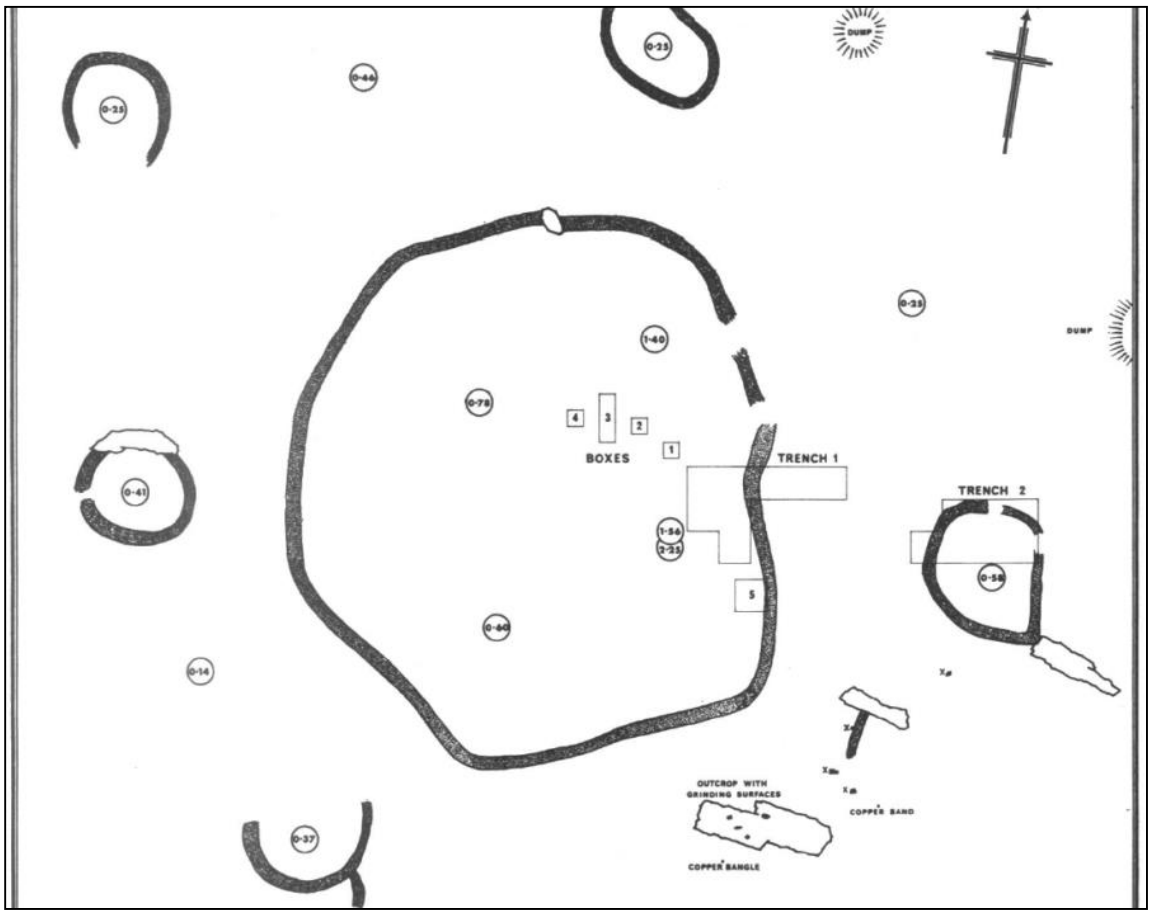

Figure 1.2: Layout of a typical Type-R settlement unit. Taken from Maggs (1971).

Over the following years more studies were carried out on the settlements and/or the human remains, including Humphreys's (1972) excavations at the site of Khartoum, and those of Brink *et al.* (1992) in Pramberg. Morris (1992) has studied the osteology of the Riet River individuals (some of which are part of this study), and therefore contributes significantly. Twenty years ago, Lee-Thorp et al. (1993) carried out carbon and nitrogen isotope analysis of bone samples from a small number of individuals from Riet River curated in the National Museum, Bloemfontein. More recently, Irish *et al*. (2014) has studied the non-metric dental traits of the Riet River skeletons, and Cameron and Pfeiffer (2014) have investigated aspects of long-bone morphology. There has not, however, been any further research on the bone chemistry of these skeletons as it relates to diet since the preliminary study by Lee-Thorp *et al*. (1993). I wish to

build on this work, developing a much more detailed picture and trying to link the analytical results to as yet unanswered archaeological questions about these communities.

Chapter Two:

Background Chapter

Climatic Conditions of the Northern Cape

The Northern Cape is one of nine provinces in South Africa. While forming part of the western component of South Africa, the Northern Cape also borders Namibia on the north-west, and Botswana, which lies east of Namibia (Fig. 1.1). While it includes a number of vegetation biomes (each briefly discussed in this section), the Northern Cape is a generally arid region with harsh climatic conditions that include minimal rainfall and long periods of drought (Schulze 1965). The temperature varies from the east to the west of the province; the western parts have a mean of 26ºC in January and a daily range of 20ºC to 34ºC, while in July one would experience a daily range of 5ºC to 21ºC and a mean of 12ºC. Temperatures in the eastern portion tend to be lower, and while summer temperatures can reach up to 45ºC during the day, they are also known to drop below zero during winter nights (Schulze 1965). These temperatures make the Northern Cape one of the driest and hottest environments in Southern Africa. Consequently, the vegetation is a direct reflection of these climatic conditions. The average annual rainfall throughout the study area is generally low, with the western portions receiving less than 250mm of rain per annum.

Vegetation of the Northern Cape

Although the Northern Cape is broadly defined by hot and dry, and semi-desert to desert environmental conditions, it includes four of the nine vegetation biomes found in South Africa. These include the Desert Biome, Nama Karoo Biome, Savanna Biome, and the Succulent Karoo Biome.

Desert Biome

The Desert Biome is characterized by extreme aridity, with rainfall of less than 80mm per annum. The Desert Biome is on the periphery of the Nama Karoo to the east, and experiences summer rainfall. On the west, the Desert Biome borders the Succulent Karoo Biome which, in contrast, has winter rainfall (Jürgens 2006). Vegetation in this environment consists of a variety of xerophytic plants that are well adapted to extreme arid conditions. As a means of adapting to the arid environment, the plants are dominantly CAM. This enables plants to use a C_4 pathway for the production of organic acids at night, which are later used during the day for the eventual

production of carbohydrates, using the C_3 pathway (Lorimer & Andrews 1981; Osmond & Holtum 1981; Bhagwat 2005).

Savanna Biome

The Savanna Biome consists of woody plants and perennial grasses, and has a rainfall of 350mm per annum (Scholes 1997). It forms part of a continuum of dry forests, deciduous woodlands, arid shrublands and lightly wooded grasslands (Scholes 1997). The climatic pattern is dominated by hot wet, and warm dry seasons. The significance of this biome is that a considerable proportion of its biomass consists of C_4 grasses (Scholes 1997). Most of the grasses in African savannah environs are C_4 grasses together with C_3 trees and shrubs (Lee-Thorp *et al.* 1993). This environment is thus extremely favourable for grazing animals.

Karoo Biome

Huntley (1984) describes three subtypes of the Karoo Biome, according to climatic, floristic, edaphic and dynamic characteristics: The arid succulent karoo is located on the west of South Africa, and receives winter rainfall. The summer rainfall central and upper karoo, which also extends into non-seasonal rainfall areas to the west and south, and the "false" karoo are all areas that have been overtaken by karroid dwarf shrubs over the last few centuries (Huntley 1984:9). Griqualand West and the south-western Free State where the Riet River settlements are found are on the boundary between Sweet Grassveld and Karoo. At least in the southern Free State and north-eastern Cape, the vegetative conditions up until 1400AD were dominated by Dry *Cymbopogon-Themeda Veld,* a true grassveld. This has since been largely replaced by the Karoo (Acocks 1988).

The Orange River lay within the Karoo belt, and the north of the river was primarily Bushveld, a vegetation zone that consists of small trees, bushy shrubs and tall trees (Morris 1992). The Karoo is an exceptionally good source of grazing, provided it is not over-grazed; the 'sweet' Bushman grass of the genus *Aristida* predominates (Acocks 1988). The Karoo bush vegetation is resistant to drought and is able to maintain its nutritional value during these conditions (Maggs 1971). On the other hand, the grasses show greater variation in response to season and drought, and in their early growth phase, they are more nutritious than the bushes (Maggs 1971). To the east of the Riet and Modder river drainage basins was the Sweet Grassveld, which was most favourable for domestic livestock as these grasses maintained their nutritional value throughout the year, so that grazing was possible even during the dry seasons (Maggs

1971; Morris 1992). Overall, these veld types made grazing possible, but were highly sensitive to overgrazing.

It is worth mentioning that the vegetation classification used by Maggs (1971) and Morris (1992) is old, whereas Mucina & Rutherford (2006) is more recent. Further, the approach and resolution from Mucina & Rutherford (2006), and Acocks (1988) are different. Both sources are used in this thesis because neither source contains all the required information.

Nama Karoo

This biome receives an average annual rainfall of only 70mm in the northwest (Mucina & Rutherford 2006). The biome is characterized by summer rainfall and unpredictable droughts, with an increase in precipitation towards the north-easterly direction (Mucina *et al.* 2006). The dominant flora includes *Fabaceae* and *Asteraceae,* and also a variety of low dwarf shrubs with grasses, geophytes, annual forbs and succulents (Mucina & Rutherford 2006). Both C_3 and C_4 grasses exist where C_3 grasses appear during winter rainfall and trees and C_4 grasses thrive during summer rainfalls (Mucina *et al.* 2006). The nature of the region allows for a host of animals to survive off its resources. This includes gramnivorous birds such as the sand grouse, and finch-larks, as well as *Antidorcas marsupialis* (springbok) and *Struthio camelus* (ostrich) (Dean 1997; Mucina *et al.* 2006). Herds of *A. marsupialis* could be seen trekking across the Karoo in search of grazing (Skinner 1993), and other herbivores including quagga, eland, hartebeest and buffalo could be seen in the region. The erection of fences and hunting has since drastically reduced herbivore numbers, and game reserves have become the main place of residence for these animals, with the exception of the now extinct quagga (Mucina *et al.* 2006).

The Succulent Karoo

This semi-desert region receives a mean of 170mm of rainfall per annum (Mucina & Rutherford 2006). The climatic conditions favour C_4 vegetation, with an average temperature of 16.8ºC (Mucina & Rutherford 2006). The biome is suitable for vertebrates such as lizards, tortoises and mole rats (Mucina & Rutherford 2006). Like the Nama Karoo, the Succulent biome has been threatened by overgrazing practices over the past century (Dean & MacDonald 1994). Prior to the introduction of livestock into southern Africa, the study area would have been covered with lush Sweet Grassveld vegetation. The advent of animal husbandry and consequent increase in both animal and human populations was the beginning of change in the environment.

Domesticated animals replaced wild migratory game. The result created increased pressure on pasture land, changing the vegetative state of the landscape (Roux & Theron 1987). Unpalatable plant species have since dominated such landscapes at the expense of their palatable counterparts.

All of the above biomes contain a mixture of both C_3 and C_4 vegetation. The C_4 vegetation consists of grasses and some shrubs, while the C_3 component consists of all trees and most shrubs and bushes. Most of the food plants that people would have exploited in these environments are C_3, except for grasses and seeds. After the summer rain, however, the C_4 vegetation grows quickly. It is during these times that C_4 plants are dominant. Because of the highly variable rainfall in these areas (Mucina *et al.* 2006), there are periods when the region receives very little rain, and animals as well as humans have to survive on mostly C_3 plants. Water played an important part in the survival and maintenance of vegetation and domestic stock in this region. The Orange River was therefore a focus of settlement in the last few centuries, and this applied throughout the period that hunter-gatherers occupied this region.

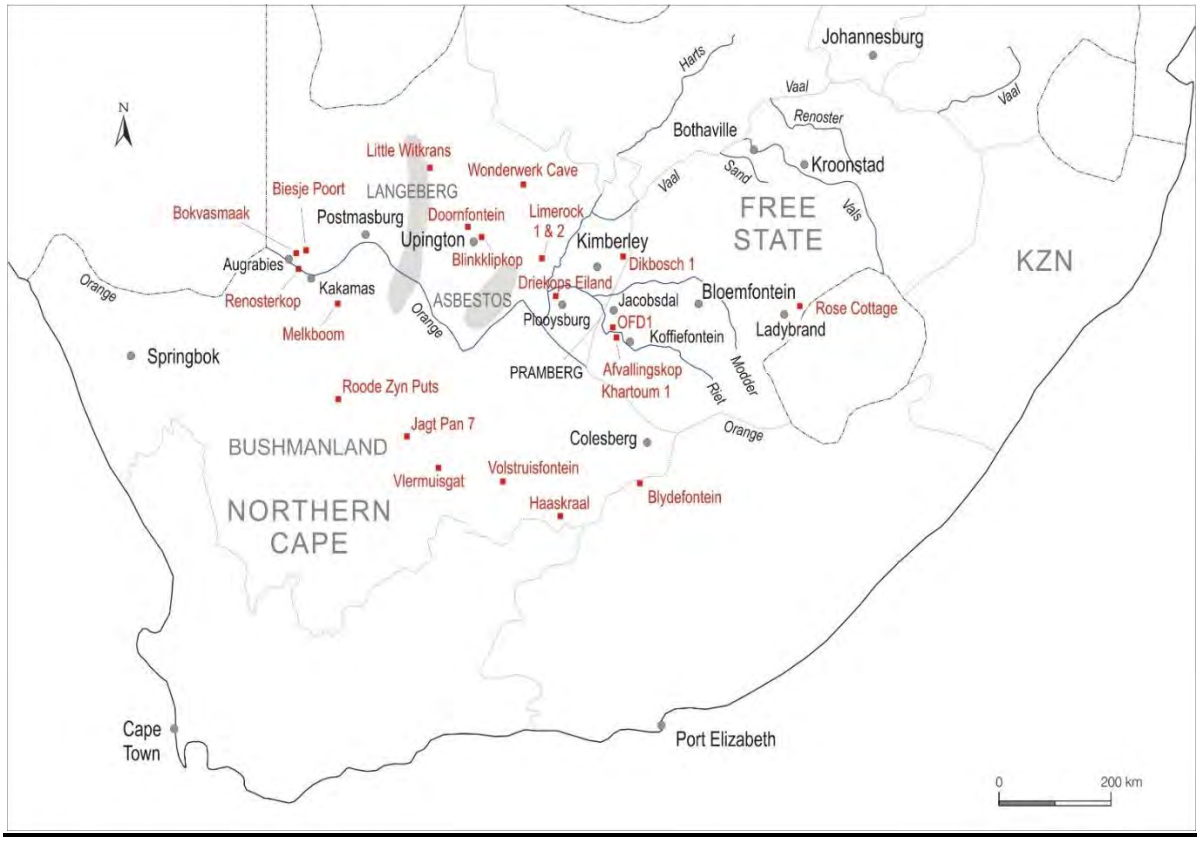

Figure 2.1: Distribution of sites referred to in the text.

The Geographical Landscape of the Northern Frontier

In precolonial times, the Northern Cape was an area of opportunity for many. It was a hunting and foraging ground for hunter-gatherer groups, as well as fertile ground for farming and herding communities. Furthermore, because of the area's position on the edge of several ecological zones, this made the area a frontier zone even in the pre-colonial period. The word "frontier" is defined as an area of interaction between at least two culturally distinct groups of people, where one group seeks some degree of control over the other (Legassick 2010). In this study, the northern frontier broadly includes eastern Namaqualand, the central Free State (previously named Transorangia), and Bushmanland (Elphick 1979). Bushmanland (Fig. 2.1), located south of the Middle Orange River, was inhabited by some of the last independent Bushmen until the early twentieth century (Smith *et al.* 2000). Central Free State is located north of the middle of the Orange River and includes Griqualand West. These territories are united by the Orange River. The frontier lies on the inland plateau of Southern Africa, rising from about 600 metres above sea level at the Bushmanland and Namibian border to over 1200 metres in the east of the Cape-Free State boundary. The Kalahari Sand System begins north of the river, while the flat plain of Bushmanland extends up to its southern banks.

The central region of the northern frontier is distinguished by the Langeberg mountain range and the Asbestos Mountains (Fig. 2.1), and contains the dolomitic Kaap Plateau. The valley of the Riet River, one of the major tributaries of the Orange River, marks the eastern region of the frontier. To the north, the Vaal-Harts valley (Fig. 2.1) forms a broad plain that ends at the Ghaap escarpment.

A Closer Examination of the Riet River Valley Landscape

The Geographical Landscape

The Riet River area receives summer rainfall, averaging about 380mm per annum (Schulze 1965). As with numerous other areas in the interior, the rainfall pattern is extremely variable. The main drainage system of the area is into the Modder and Riet Rivers (Fig. 2.1) which have other minor stream tributaries. The area has several pans which fill up with water after heavy rains, and because some pans are unable to hold water for prolonged periods, the water supply depends on the rainfall. Additionally, as a result of the extremity of the temperature in this area, precipitation is exceeded by evaporation. While January is the hottest month, with temperatures of up to 38ºC, winter temperatures are known to plummet below freezing (Wellington 1955).

The Riet River area's location between the Northern Cape, the Free State, and the harsher area of the Karoo, places it within the marginal category in terms of drought-vulnerable areas in South Africa (Humphreys 1972).

The Vegetation

The Riet River area is distinguished by differences in vegetation types between the eastern and western portions. In the year 1400 AD, the eastern section consisted of Sweet Grassveld, while the western section was Bushveld (Acocks 1988). The Sweet Grassveld consisted of a broad-leaved evergreen grass, *Tetrachnedregei,* which provided good grazing. This biome has since been largely replaced by Karoo-Type vegetation (Acocks 1988). The western portion is said to have been Bushveld which has now degenerated to Kalahari Thornveld overrun by Karoo. The Karoo type vegetation is highly resistant to drought, and plants are able to retain their nutritional content. This has different implications for each veld type in terms of the carrying capacity. While grassland areas would have high carrying capacity during the best season, they deteriorate in winter and the nutritional value for stock decreases. The Karoo, on the other hand, has lower carrying capacity but is able to provide all year round nutrition for stock (Humphreys 1972).

Faunal Distribution

In the early 1960s R.C. Bigalke and J.A. Bateman conducted a survey of the distribution and status of ungulate and sub-ungulate mammals in the former Cape Province (Humphreys 1979). Questionnaires listing the various species of ungulate mammals that might be expected to occur in the area were sent to farmers. The results of the survey for the two districts through which the Riet River flows, Kimberley and Herbert, are shown in Table 2.1. Skead's (1980) extensive compilation of mammals that would have existed in South Africa during the historic period, as shown by historic accounts of numerous European explorers of the nineteenth centuries, indicates that some ungulates that are not represented in the table below did exist in the Northern Cape. The bush pig and warthog are not known to exist in the Northern Cape. However, they were observed not far from the Northern Cape boundary, immediately east, in the Free State (Skead 1980). Bushmen would have also hunted big mammals such as elephants, also sighted in the Northern Cape, though it appears that by 1839 they were no longer observed in some areas of the Northern Cape, such as Postmasburg. Other animals that are known to have inhabited the drier interior, including the Bushmanland and Karoo regions, include porcupines and hares.

Table 2.1: Large mammals in the Kimberley and Herbert districts of the Cape Province during the 1960s. Figures indicate percentage of farmers' responses reporting species being present (from Humphreys 1979).

Ungulate	Kimberley	Herbert
Aardvark	62,1	67,3
Dassie	37,1	52,2
Tree Dassie	0	0
Mountain Zebra	0	0
Bush Pig	0	0
Warthog	0	0
Blue Duiker	0	0
Duiker	90,3	52,2
Steenbok	95,2	95,6
Grysbok	0	0
Oribi	0	0
Klipspringer	0	1,8
Vaal Ribbok	11,3	7,9
Rooi Ribbok	4,8	2,7
Springbok	80	66,4
Gemsbok	1,6	1,8
Blesbok	16,1	23,9
Hartebeest	9,7	1,8
Black Wildebeest	3,2	1,8
Bushbuck	0	0
Kudu	17,7	20,4
Eland	3,2	0,9

History of Occupation along the Orange River and its Tributaries

The Orange River played a pivotal role for prehistoric societies who lived along its course: as a source of much needed water as well as food resources, it was an environment from which life could sustain itself. Knowledge of the early prehistoric background of this area is fragmentary. Evidence indicates widespread occupation in the Early and Middle Stone Age periods (Sampson 1974; Morris 1992). Although the river itself was likely always a focus for human settlement, areas away from the river show marked fluctuations in population density over time. The arid and warm environmental conditions of the mid-Holocene period, between 8000-4000 BP, led to low population densities in the Karoo and parts of the Northern Cape (Deacon 1974; Humphreys 1979). The archaeology suggests rapid reoccupation of the interior after 4000 BP as a result of improving environmental conditions which would have been ideal for many

species of game as well as livestock as a result of the return of marginal grassland vegetation (Humphreys 1979).

San groups to the east and south east of the Orange River Valley took advantage of the river and its resources (Wellington 1955). The Orange River presented a series of natural barriers which, undoubtedly, Khoe pastoralists could use to their advantage. This is because the ownership of livestock not only placed them at risk of being raided by both San and Bantu-speaking groups, but the urgency of finding a reliable water source and good grazing pasture increased (Wellington 1955; Penn 1995). The Middle Orange River provided exactly that- with numerous islands and the desert and semi-desert regions into which the river flowed, the survival and protection of both stock and humans was ensured (Wellington 1955; Penn 1995).

The relationship that (at least) the Khoekhoe had with the San during pre-colonial times was by no means a simple one. Broadly speaking, the San were viewed as inferior by both neighbouring Iron Age groups and pastoralists and therefore were assigned the lowest social status. Even so, the San were excellent environmental adapters and were well-informed on the landscapes on which they traversed. For this they were used by Khoekhoe groups and Iron Age farmers for their hunting skills as these two groups still relied on wild game. In return, the San were given milk or lambs. The dynamic, fluid and contextual nature of these two economic groups meant the long term ownership of livestock was not always guaranteed as some Khoekhoe individuals lost herds and reverted to a hunting and gathering lifestyle (Boonzaier *et al.* 1996). Similarly, the role played by the San was important for Iron Age agro-pastoralists, often performing tasks ranging from hunting to rainmaking (Smith *et al.* 2000).

Unfortunately, the task of understanding how the Orange River area was used during prehistoric times poses a challenge, as sites in the area that contain undisturbed stratigraphic sequences are few and far between. Further, as modern agriculture and siltation of the river's floodplain is a regular feature in the area, sites are often buried (Beaumont *et al.* 1995). Research of the area during the 1970s, particularly in Bushmanland, has opened up a discussion on: firstly, the nature of the Orange River Valley as a means of people's survival and secondly, consequent relationships that people had, not only with their environment, but with each other. Evidence of this will be illustrated by archaeological sites throughout the Northern Cape.

Dikbosch 1 (Fig. 2.1), located about 14km east of the Vaal River contains a sequence that begins about 13000 years ago (Humphreys & Thackeray 1983). The ceramic assemblage, similar to that of Little Witkrans and Wonderwerk Cave, is grit-tempered. The site experiences

an extensive occupation between the years 13000 BP to 12000 BP, which is followed by a gap. At around 3000 years ago, another occupation period ensues. Humphreys & Thackeray (1983:151) suggest that the vertical movement of artefacts through the soft deposit makes it difficult to assess patterning in artefact distribution. Scrapers were the most frequent retouched pieces, as well as backed pieces in the upper levels.

Situated in the eastern Karoo, Blydefontein Rock Shelter provides a cultural sequence that records sporadic occupation by LSA hunter-gatherers during the terminal Pleistocene and Holocene (Fig. 2.1)(Bousman 2005). The technological shifts from microlithic to macrolithic stone assemblages are represented by the Robberg, Lockshoek, Classic Wilton and Smithfield industries. The Robberg assemblage for the rock shelter includes high bladelet frequencies, and smaller number of unifacial scrapers. Microlithic backed tools are scarce. Robberg assemblages in Southern Africa date anywhere between 22 000-12000BP, with dates of 11850±150BP for Blydefontein and 9560±70BP (Pta-7275) for Rose Cottage Cave (Bousman 2005). Lockshoek is the name given to the Karoo variant of the Oakhurst Industry (Sampson 1974). The Lockshoek assemblage in this site includes large flakes and unifacial scrapers, and rare cores (Bousman 2005). A date of 8541±417BP (SMU-1823) was obtained (Bousman 2005). The Classic Wilton assemblage consists of microlithic tools such as backed crescents and small end scrapers. A radiocarbon date is not available for this assemblage, however, a date of 4286±149BP (SMU-1852) for Layer CAC above indicates that occupations did occur during the mid-Holocene but scantily. Layers with end scrapers and straight-backed bladelets dating to between 4300-2300BP belong to the Developed Wilton Complex while those with fibre-tempered and herder (associated with herder occupation in the Seacow Valley) ceramics fall under the Ceramic Wilton Complex (Bousman 2005). Lastly, the Smithfield assemblage of at least the last 200 years includes decorated fibre-tempered ceramics and long end scrapers (Bousman 2005). The sequence indicates that, at least in the late Holocene, both hunter-gatherers and herders occupied the site.

At Wonderwerk Cave (Fig. 2.1), material dated between 10200±90 BP (Pta-2786) and 1210±50 BP (Pta-2779) indicates various periods of occupation of the site over the last 10000 years. The most notable artefacts to have been recovered in any layer were macrolithic non-retouched tools. Retouched artefacts make up only about 4% of the total assemblage, mostly scrapers (Humphreys & Thackeray 1983). The period between 10000-8500 years (layer 4d) contains no backed artefacts, and scrapers are larger and made on ironstone. Similarly, the Oakhurst assemblage of Rose Cottage Cave (Fig. 2.1), although it spans a period of only about a

thousand years from 9250±70BP (Pta-5599) to 8160±70BP (Pta-7122), is dominated by medium-sized scrapers in the three earlier layers (Wadley 1991; 2000a). Pollen and microfaunal remains reflect dry climatic conditions which indicate scrub type vegetation during the period which the producers of the 4d assemblage inhabited the site of Wonderwerk Cave (Humphreys & Thackeray 1983). At Rose Cottage Cave, the Oakhurst industrial period saw changes from cooler and moister conditions to those more like the present (Wadley 2000a). Between 8500BP and historic times Wonderwerk Cave has yielded a different lithic assemblage, dominated by backed blades (as in Rose Cottage Cave), segments, large and small scrapers, notched artefacts and decorated ostrich egg shell (Humphreys & Thackeray 1983; Wadley 2000b). Additionally, unlike the assemblage in layer 4d, this industry also contains bone artefacts. Climatic conditions became moister between 9000-5000BP and therefore the vegetation cover of the area changed to grass, bushes and trees. The animals represented throughout the sequence include hartebeest, zebra as well as small mammals such as tortoises (Humphreys & Thackeray 1983). The implication, in terms of landscape use, is that the difference in technological strategies between the early and mid-Holocene industries was in response to changing environmental conditions.

The sequence at Little Witkrans extends between 7500-1500BP (Humphreys & Thackeray 1983). Scrapers and backed artefacts prevail in the retouched lithic assemblage. All recovered pottery is grit-tempered, as is the case at Wonderwerk Cave (Humphreys & Thackeray 1983). Further, the stratigraphic position of the sherds indicates a date of at least 1500 years for the appearance of pottery in the Northern Cape (Humphreys & Thackeray 1983). The use of fine-grained material like quartz and chert between the extrapolated dates of 7000-4000BP correlates with the production of blades and retouched artefacts (scrapers and backed blades), similar to the assemblage found around the same period in Wonderwerk Cave (Humphreys & Thackeray 1983).

The site of Waterval (Fig. 2.1) is part of the Augrabies Falls National Park, and is located on the northern bank of the Orange River. Two grids were set up and excavated, namely Waterval Grid 1 and Grid 2. A hearth uncovered from Grid 1 provided a charcoal sample which produced a radiocarbon date of 760±40BP (Pta-3847) (Smith 1995). The material culture lacks formal tools, although there are some miscellaneous retouched pieces. Other finds are thin-walled and grit tempered ceramics, a copper object, and faunal remains that include a sheep mandible, small to large bovids, as well as fragments of freshwater mussel (Smith 1995). Two seeds of the tree *Ziziphus mucronata* were also recovered. In his journey along the river during the late 18th

century, Wikar mentions this tree which he calls the 'wagt-een-bietjie', also called 'haap', as a source of food for Bushmen he encountered (Mossop 1935: 59). Overall, Smith argues that this site implies Khoe occupation along the Orange River as shown by the presence of the sheep and the absence of a specialized lithic technology.

In contrast, Droegrond (Fig. 2.1), located 55km southwest of Kakamas (Smith 1995), is one of a few sites some distance from the river, and therefore holds clues to land-use patterns in these areas. Its position next to an aquifer meant that groups of individuals who occupied the site were guaranteed a source of water, a feature not universal in the arid area. Excavations of two areas in the Droegrond farm, DrA and DrB, point to foraging groups as the occupiers of the site. A date of 400±120BP (Pta-2396) for DrB was obtained on charcoal from the lowest unit (Smith 1995). The lithic assemblage in both excavated areas is microlithic, and a large proportion was made on quartz. Highly fragmented ostrich egg shell was also recovered. The farmer recovered a cache of ostrich egg shells with holes on one end, probably storage containers (Smith 1995). Grass-tempered potsherds with rim decoration, as well as glass beads were recovered, an indication of trade by (at least) the 16th century. Iron metal suggests trade with Tswana groups to the north, and the remains of wild game including springbok, as well as hare, small antelope, dassie and tortoise point to a hunting economy.

In the Northern Cape Province, two industries have been suggested to belong to distinct socio-economic groups. The Swartkop Industry, which is found mainly near water sources such as streambeds and pans, as well as near koppies, has been ascribed to hunter-gatherers (Beaumont & Vogel 1989; Beaumont *et al.* 1995; Parsons 2003). It is characterized by a predominantly hornfels formal toolkit, and undecorated, grass-tempered ceramics which are more frequent in the later assemblages. Iron objects are occasionally present (Beaumont *et al.* 1995; Parsons 2007). Sites that have been identified include Roode Zyn Puts 2-5, Jagt Pan 7 and Vlermuisgat. In contrast, Doornfontein-type sites (such as Biesjepoort, Bokvasmaak 3 & 4, and Melkboom 1) are located near the Orange River or other water sources near the river (Fig. 2,1)(Beaumont *et al.* 1995). The lithic component of the Doornfontein Industry is largely quartz, with few, if any formal tools. The frequency of ceramics is higher, and they are thin-walled with decorations on the rim or neck. Lugs and spouts are also present, with some ceramics having thickened bases. Amphora-shaped pottery like this has been associated with the Khoekhoe through historic records (Beaumont *et al.* 1995). There is also an increase in the frequency of copper and iron objects, and the ostrich eggshell bead size is larger. Grinding grooves and larger bone points, which are not a hunter-gatherer attribute, feature in this industry (Parsons

2007). This industry, it is argued, contains a herder signature (Beaumont *et al.* 1995; Parsons 2003 & 2007).

Parsons (2007) argues that the small sample sizes and variability between assemblages makes the task of confidently assigning sites to either one of the industries a challenge. This is made apparent by the presence of a high number of blades and bladelets at Jagt Pan 7 and their absence at Vlermuisgat, both considered to belong to the Swartkop tradition. Ostrich eggshell bead diameters from the sites of Biesje Poort 2 and Bokvasmaak vary, and grass-tempered potsherds were identified in Bokvasmaak, Biesje Poort 2 and Vlermuisgat. Such variability "emphasises the need for more research" (Parsons 2007: 9).

The sites of Renosterkop (Renosterkop 1 and 2) whose finds indicate a herder occupation, as well as historical documentation by Wikar and Gordon give a glimpse of the lifeways of pre-historic herder groups (Fig. 2.1). This includes the Namneiqua of !Nawabdanas who occupied the islands between Augrabies Falls and Kakamas and their interaction with other neigbouring groups such as the Anoe eis of Augrabies and the Geissiqua who had contact with Iron Age Tswana groups to the north-east (Morris & Beaumont 1991). The Renosterkop 1 assemblage consists of ceramic components which make up about 21% of the total assemblage inventory. The herder associated pottery is thin-walled and grit-tempered. Grass-tempered ceramics are also present, but in lower frequencies. Pointed bases, lugs and bosses appear to have been attributes on some of the thickened sherds, and "decoration, confined to rim sherds, consists of incised horizontal lines and stamp drop-shaped patterns. Rims are plain with tapered and squared examples" (Morris & Beaumont 1991: 118). The stone tools included only 0.6% formal tools and up to 79% unretouched flakes (Morris & Beaumont 1991). Other artefacts include ostrich egg shell beads and an iron fragment. Renosterkop 2 produced flakes and stone tools with the same characteristics as Renosterkop 1. Ochre, coarser pottery and ostrich egg shell beads, whose size "may vary between earlier and later herder phases", were also recovered (Morris & Beaumont 1991:119). Further, the presence of metal on both sites not only indicates the possibility of contact with Iron Age communities, but shows that metal working may not have been an alien concept for the Khoe (Morris & Beaumont 1991).

Sampson's (1988) work on the Upper Seacow Valley indicates the production and use of pottery by hunter-gatherer bands in various areas across the 2000 km^2 study area. It has been proposed that variations in ceramic decoration across the area may be boundary markers reflecting socioterritorial boundaries or symbolic meaning (Sampson 1988). Excavations in eight

sites including Haaskraal and Volstruisfontein Rock Shelters (Fig. 2.1) have shown that there is variation through time in pottery types, as well as differences in the sequences across sites (Sampson *et al.* 1989). The work done by Sampson and his team clearly indicates a vibrant history in the Seacow Valley in the second millennium AD, with at least five major ceramic stylistic transitions within the last thousand years. Some of these may be related to declining climatic conditions and pressure on resource availability, e.g. during the period 1350-1500AD in which the KwaZulu-Natal tree-ring record indicates cooler-drier climatic conditions. The rapid appearance of clusters of distinct styles of ceramic decoration at this time may reflect social stress amongst hunter-gatherers, and the possible retreat of Khoi herders (Sampson *et al.* 1989). Twenty-one years later, the use of direct thermoluminescence dating of fibre-tempered potsherds from the upper Seacow River Valley validates the rich history of the area, as occupied and used by its inhabitants, hunter-foragers, hunters-with-sheep, and herders (Sampson 2010).

Archaeological evidence from burials excavated along the Riet River also indicates interactions between these Riet River 'Bushmen' herders and Iron Age Bantu-speaking groups to the north and north-west (Humphreys 1970; Humphreys and Maggs 1970; Humphreys 1982; Maggs 1971; Morris 1981). The presence of earrings made of sheet copper, which are specifically associated with the Sotho-Tswana, strongly suggests trading between these two groups (Maggs 1971; Morris 1981). Among the Tswana, sheet copper earrings were worn by high-status men (Burchell 1953). The cone-shaped earrings recovered from Riet River burials and referred to by Humphreys as 'candle-snuffers' are also made from sheet copper (Humphreys 1970). In addition to the indication of copper trade, other grave goods including cowrie shells and glass beads have been recovered (Appendix 1). These items, which are certainly not indigenous to the interior, not only indicate long distance trade, but also raise further questions of other items that might have been traded, such as food items like grain and domesticated animals. In the second millennium CE, Iron Age farming societies occupied territory to the north and east of the Riet River. They grew crops, and also kept cattle and small stock with cattle, in particular, occupying a key position in the subsistence economy, as a means of accumulating wealth, and as a central element in the ritual and symbolic world. The possibility of trade should be looked at in the context of these neighbouring groups. It is thus worth reviewing the area of distribution of Iron Age settlements and how this relates to the difference in subsistence strategies by each community.

In the 1960s, T.M. O'C Maggs initiated a study on the Iron Age of the Free State. In the initial phase of the project, Maggs (1976) analysed aerial photographs of the whole area and identified two main Iron Age settlement types. Subsequent to this, he carried out fieldwork to explore in more detail the layout of the settlement types identified in the aerial photographs, to which the terms Type Z and Type V were assigned. The Type V settlement units are found throughout the north-eastern Free State as far south as Ladybrand (Fig. 2.1), where the OND3 type site is located, to what was then called the south-eastern Transvaal in the north. They are "a true Highveld expression of the Iron Age…in the area of Highveld Prairie soils with a rainfall of 600-800mm" (Maggs 1976: 29). They are characterised by a number of primary enclosures assembled in a ring, linked by secondary walling to form a secondary enclosure. It is into this secondary enclosure that the entrances of the primary enclosures open. While it is thought that some of the primary enclosures were used as livestock pens, some seem to have been huts.

Type Z settlements, on the other hand, are located in the valleys of the Vals, Renoster and Sand rivers in north-western Free State (Fig. 2.1). The main distribution of Type Z settlement units is along the central Free State escarpment where the rainfall reaches about 600mm. A few occur in Bothaville (Fig. 2.1), an area that receives about 550mm of rain, and marks the limit of Iron Age settlement distribution since drier areas are unsuitable for the cultivation of Iron Age crops. Type Z settlements are characterised by a number of large primary enclosures which make up the central group of the settlement unit. Around the central groups are bilobial dwellings, consisting of huts with front and back semicircular courtyards (Maggs 1976). It thus comes as no surprise that the drier western interior where the Type-R (Type-R derived from Riet River) settlements occur was occupied by a society whose subsistence habits included herding, while the wetter eastern and northern areas were occupied by Iron Age farmers who relied on rainfall for the cultivation of crops such as sorghum and millet, to which the Type-R society might have gained access through trade. The use of isotope chemistry together with archaeological evidence allows for the investigation of such questions.

The above mentioned sites not only show the challenge in understanding the prehistoric situation of the people of southern Africa. It also attests to the situation of prehistory along the river and its hinterlands, a complex web of relationships over a long period. Nonetheless, the dynamism and fluidity that was elemental for the survival of all groups involved was not enough, for colonialism made its way into, and changed the lifeways of its indigenes forever.

So how did Pastoralism Come About?

Early researchers proposed that stock-keeping spread as the result of a gradual movement of Hamitic herders into East Africa and then to the Cape through Zimbabwe, Botswana and Namibia (Von Loschan 1907). Later researchers (Smith 1983) placed the origins of pastoralism in northern Botswana. Smith suggested that the need for new grazing pastures resulted in the migration of herders and their livestock to the Cape about two thousand years ago (Smith 1983). Two routes have been proposed: one from northern Namibia down the west coast and through to Little Namaqualand to the Cape (Stow 1905). Elphick (1977) suggested an alternative route through central Botswana to the confluence of the Orange and Vaal Rivers, then a split so that one group moved westwards along the Orange River towards the Atlantic coastline, and subsequently northwards into Namibia and southwards towards the Western Cape. The other group, he proposed, travelled in a southerly direction through the central Karoo towards the south coast and reached the Cape (Elphick 1977; Bousman 1998). Supporters of these migration hypotheses generally see stock-keeping and other new cultural practices, notably the manufacture and use of pottery, spreading as a 'package'.

The implications of each theory are relevant to early herding along the Riet River. Stow's (1905) proposed route implies that herders would not have occupied these areas until relatively recently. Elphick's (1977) model, on the other hand, implies herder occupation of the Orange River valley as early as two thousand years ago. Evidence of early herders in the Northern Cape is sparse, resulting in divided opinions. While Beaumont & Vogel (1984) are strong proponents of the early movement of pastoralists into the Northern Cape as early as two thousand and fifty years ago, Klein (1979) believes that the early dates they cite are a result of compromised excavation procedures. The Einiqua, a Khoekhoe pastoral group, is known to have occupied the middle and lower Orange River by the late 1700s, but it is unclear when this occupation began (Mossop 1935).

Sadr (1998) has pointed out that there is marked regional diversity in early pottery styles (e.g. at Toteng, Geduld, Bambata and Kasteelberg), and that this is inconsistent with ceramic technology having spread as a result of migration (Fig. 1.1). In addition, he notes that at some sites such as South Africa's Kasteelberg A (KBA) and Die Kelders, sheep remains are younger than the pottery-bearing layers (Sealy & Yates 1994) while at other sites such as Spoegrivier (Fig. 1.1) in the Northern Cape, the opposite is true (Vogel *et al.* 1997). Sadr (1998) argues that these features are more consistent with a diffusion hypothesis in which pottery and stock spread

by being passed on to neighbouring groups, without significant movement of humans. He suggests that there may have been a later migration, and uses evidence of lugged pottery to argue for the later arrival of Khoekhoe groups early in the second millennium AD. He points out that there is documentary evidence that seventeenth-century Khoekhoen potters made lugged pottery. In addition, the areas where archaeological examples of pierced lugs have been found fall along the suggested migration routes of the Khoekhoen. Nevertheless, factors such as the scarcity of well-dated assemblages, small sample sizes and lack of published data make tracing the Khoekhoe archaeologically a challenge, with the exception of Kasteelberg (Sadr 1998).

Smith (1990) sees hunter-gatherers and herders as having very different world views. He argues that Bushman ideology, especially their egalitarian social system, the lack of a delayed-return economic system, and the absence of symbolic beliefs involving livestock, would have made it impossible for hunter-gatherers to become herders, since this would have required incorporation into a hierarchically based society centred around the accumulation of cattle and the concept of wealth. Sadr (1998) considers these theoretical factors but maintains that the boundaries between hunters and herders would have been more fluid. He argues that, first, Smith's hypothesis assumes that all prehistoric hunter-gatherers held the same egalitarian views, which would have made it difficult for any of them to make the transition to herding. Second, the implication is that the earliest livestock- and pottery- keeping LSA people were fully committed pastoralists, similar to the historically described Khoekhoe. In fact, there are a number of features in the archaeology of first millennium AD sites that are markedly dissimilar to the Khoekhoe pattern, especially the rarity of cattle bones. Kent (1992), like Sadr, opposes Smith's view, highlighting the social and cultural diversity amongst, and fluidity within hunter-gatherer groups. The diversity ranges from language to historical circumstances which are expected to have varied as a result of the large number of hunter-gatherer groups who lived in very different environments (Sadr 1998). The importance of differentiating subsistence strategies which encompass livestock such as pastoralism, agropastoralism and hunter-herding, is greatly stressed by Sadr. Ninety percent of hunter-herder diet consists of wild food resources and only up to 25% comes from livestock. Archaeological sites like Boomplaas (Fig. 1.1) in South Africa, Geduld in Namibia and Bambata Cave in Zimbabwe attest this observation (Klein 1978; Walker 1983; Smith *et al.* 1995; Bousman 1998). These small percentages do not mean hunter-gatherers could not acquire and keep livestock, as indicated by the Kutse of Botswana who spend only 9% of their time on herding and cultivation (Kent 1992).

Contrary to the purely Khoesan model for the introduction of domestic animals into southern Africa, Bousman (1998) suggests that, at least in the northern and eastern parts of South Africa, Early Iron Age communities were also involved. Based on numerous lines of evidence including linguistic analysis, ethnographic data, rock art and genetic studies, the author suggests that the complex and fluid interactions of Iron Age and Khoesan communities would have played a role in the introduction of the domestic animals into southern Africa.

In the last ten years, the debate on the advent of pastoralism has developed new lines of evidence, which have nonetheless brought little finality in as far as settling the matter is concerned. Sadr (2008) continues to argue that LSA pastoralism in southern Africa was a 2nd millennium AD phenomenon, and that the evidence is inconsistent with the migration hypothesis. Other lines of evidence have been brought forward by proponents of the migration model, who propose that linguistic, genetic, archaeological, and ethnographic work validate the evidence for an early Khoekhoen presence in southern Africa, for example, through the presence of a nonentoptic geometric rock art tradition that has been found along watercourses, particularly in South Africa's central interior (Smith & Ouzman 2004). This includes finger-printed and engraved geometric images in the Central Limpopo Basin, which have been linked to the presence of early herder groups there in the 1st millennium AD (Eastwood & Smith 2005). In the western part of South Africa, Orton *et al.* (2013) use a dated cattle horn (*Bos taurus;* 1625±25BP*)* from KN2005/041, a site located in Namaqualand to argue for a migration route through Namibia into southern Africa in the early 1st millennium AD.

Sampson's (2010) study of the prehistory of herding in the upper Seacow Valley documents herders, hunters-with-sheep, and hunter-foragers on the same landscape. This is important because not only does it bring about awareness of the practice of herding in the area. It suggests the forging of complex relationships amongst its inhabitants, through the interaction of borrowed and/or adapted cultures between hunters and incoming herders.

The questions surrounding this debate are really concerned with the lifestyles of the individuals who possessed livestock. It is relevant to this debate to explore the importance and role of herding in the subsistence and trading economies of Riet River communities, who were described by Burchell (1953) as 'Bushmen', largely because they spoke a Bushman language. This issue will be investigated in this thesis using stable isotope analysis.

Hunter-Gatherer and Herder Subsistence Bases

Research carried out in the Riet River area by Maggs (1971) and Humphreys (1972) described what are now known as the Type-R settlement sites. These sites were initially documented by Van Riet Lowe (1929; 1931). Further investigation of the settlement structures by Maggs was carried out in the early 1970s, in the form of an excavation of the site, OFD1, on the farm Oudefontein (Fig. 2.1). The site is located 12 km north-west of Koffiefontein, and contains thirteen settlement units, the largest cluster of all Type-R sites. Amongst the various artefacts recovered were copper objects which included a bead and bangles, as well as a small sample of faunal remains (Appendix 1; Table 2.3). These are important for enquiring into the importance of herding compared with hunting in the local economy, and an indication into the extent of communication for trade with neighbouring farming communities to the north and east of the Riet River area. Investigation of the Settlement Unit Khartoum 1 on the farm Langhoek in the Jacobsdal district, was carried out by Humphreys (1972) (Fig. 2.1). At both OFD 1 and Khartoum, none of the bones of large mammals could be securely identified to species. Size Class 2 may include domesticated sheep/goat, but these specimens may also have come from wild animals such as springbok. Size Class 3 may include cattle, but these bones could also derive from wildebeest, hartebeest or zebra. It is on this basis that Humphreys (1972) put forward the proposition that hunting and gathering was the primary means by which people of the Riet River area subsisted. This suggestion is further supported by evidence from a rescue excavation at Pramberg, Jacobsdal, in which domestic stock is a minor component of the faunal assemblage (Brink *et al.* 1992). These results are consistent with a study by Lee-Thorp *et al.* (1993) that looked at the subsistence and dietary habits of prehistoric farming communities in South Africa, using isotopic methods. For comparative purposes, Lee Thorp *et al.* (1993) included nine individuals from the Riet River area. The carbon and nitrogen isotope ratios of this community were found to indicate a combination of C_3 and C_4 foods, probably with considerable reliance on wild plant foods. Gilbert (1995) used stable isotope analysis to investigate the diet and subsistence patterns of Late Iron Age people in South Africa. In the attempt to understanding the extent of trading relations between the Riet River communities and their Iron Age neighbours, it would be interesting to compare the distribution of carbon and nitrogen isotope values of the two groups. This issue will be discussed in more detail further on in the thesis.

Meat in Khoekhoe and San Hunter-Gatherer Diets

In the late 1960s, G.P. Murdock (Elphick 1977) showed that almost 30% of African pastoralist economic practices involved hunting, with energy expenditure similar to that of San hunter-gatherer societies (Morris 1992). Like the San, the Khoe relied primarily on wild game for the meat component of their diet. Although the Khoe consumed their livestock, such events were rare as stock were of important social and economic value, and were slaughtered only for special ceremonies. Even the supply of milk was not always reliable as its availability largely depended on the quality of pasture and the presence of calves (Elphick 1985; Morris 1992). Bantu-speaking farmers south of the Zambezi (Fig. 1.1) are known to have hunted, although the percentage is much lower than that of the San and Khoe hunters (Morris 1992). Khoe pastoralists certainly relied more on wild game than their Bantu-speaking neighbours as they did not practice cultivation. Their more mobile lifestyle lent itself to hunting, and unlike the Bantu-speakers, Khoe men could leave their livestock under the women's' supervision while they went hunting (Elphick 1985).

Meat is important in both Khoe pastoralist and San hunter-gatherer diet. However, research has shown that even though San hunter-gatherers relied on hunting and gathering for survival (meat contributed about 20% for the !Kung), meat was a greater component for Khoe pastoralists (Elphick 1985). The consensus that hunter-gatherers consume large amounts of meat has been challenged based on research done on !Kung and Gw/i hunter-gatherers (Silberbauer 1981). According to Silberbauer (1981) the frequency of meat consumption largely depended on seasonal fluctuation and its availability in the landscape. Tortoises are amongst the most hunted animals in the Kalahari, with a total of up to 90 collected between December and February. Rodents are the next most available and hunted animals, reaching up to 40 in May, followed by springhare (up to 30 captured in April). These smaller animals seem to have contributed a major portion of hunter-gatherer diet as the larger eland, duiker, and springbok were the least hunted (Silberbauer 1981). Madsen & Schmitt (1998) propose that the extent to which a species is exploited changes its rank. Hunted singly, a rodent is a low-ranked species as its size is small. However, if the rodents are hunted in a cluster, they will have a greater return than hunting a single eland (Dewar *et al.* 2006).

The Northern Cape archaeology supports the ethnography. Sites investigated by Humphreys and the Thackerays, some of which are described above, have yielded food remains relevant to this issue (Table 2.1). The sites indicate the regular consumption of small animals such as

dassie, tortoise, rock rabbit and hare, and the consumption of larger animals including gemsbok, springbok, wildebeest, sheep and steenbok (Humphreys & Thackeray 1983). All the sites yielded incomplete remains of large-sized fauna, an indication of butchering away from the sites and subsequent transportation back to the sites (Humphreys & Thackeray 1983). Although the faunal remains reflect the nature of the diet of these groups, the small samples makes it difficult to recognize any patterns of seasonality or specialization (Humphreys & Thackeray 1983).

The faunal remains at these seven sites make it possible to suggest what the diets of the local communities were, and to make inferences as to the likely carbon isotope values. Modern browsers such as dassie and tortoises are expected to indicate depleted $\delta^{13}C$ values as a reflection of a C_3 dietary component. A $\delta^{13}C_{(collagen)}$ average of -22.9‰ and -21.4‰ has been reported for tortoises and dassie, respectively, in Bushmanland, Northern Cape (Sealy *et al.* 1986). $\delta^{13}C_{(collagen)}$ are expected to be heavier for mixed feeders such as springbok and steenbok, and grazers such as hares. A value of -17.4‰ was reported for steenbok of the Karoo Proper, and -18.5‰ for the steenbok of Bushmanland, while the values for springbok are -19.0‰ and -18.4‰ for the same regions, respectively (Sealy *et al.* 1986). It should be noted that values may have been somewhat different in the past, at times when the veld was less heavily grazed than it is today. Additionally, these values are 1.5‰ more negative than they would have been in pre-colonial times, because of the fossil fuel effect.

Table 2.2: Fauna and flora recovered from archaeological sites in the Northern Cape.

Site Name, location, date & reference	Number of large fauna	Number of small Fauna	Evidence of Flora
Blinkklipkop 28°18'0.32"S; 23°6'59.95"E Date: 80-1000 BP (Humphreys & Thackeray 1983: 100-103; Google Earth).	Ungulate Class I*: ±70 Ungulate Class II**: ±28 Ungulate Class III***: ±20 (Humphreys & Thackeray 1983: 138, Table 28).	Tortoise: ±30 Hare: ±5 Rock Rabbit: ±5 (Humphreys & Thackeray 1983: 138, Table 28).	None found
Wonderwerk Cave 27°50'48.55"S; 23°33'15.02"E Date: 10000-1000BP (Humphreys & Thackeray 1983: 35-45; Google Earth).	Ungulate Class I: ±14 Ungulate Class II: ±14 Ungulate Class III: ±56 (Humphreys & Thackeray 1983: 135, Table 26).	Tortoise: ±30 Hare: ±14 Dassie: ±15 (Humphreys & Thackeray 1983: 135: Table 26).	None found
Dikbosch 1 28°40'26.94"S; 23°55'45.70"E Date: 13000-1000BP (Humphreys & Thackeray 1983: 148-159; Google Earth).	Ungulate Class I: ±13 Ungulate Class II: ±5 Ungulate Class III: ±24 (Humphreys & Thackeray 1983: 227, Table 40).	Tortoise: 0 Hare: ±6 Dassie: ±0 (Humphreys & Thackeray 1983: 227, Table 40).	None found
Dikbosch 2 1km north of Dikbosch 1	Ungulate Class I: ±10 Ungulate Class II: 1 Ungulate Class III: ±2 (Humphreys & Thackeray 1983: 238, Table 53).	Tortoise: 1 Hare: ±2 Dassie:±2 (Humphreys & Thackeray 1983: 238, Table 53).	None found
Limerock 1 & 2 28°33'1"S; 24°0'8"E Date: 1700-1400BP (Humphreys & Thackeray 1983: 192-205).	Ungulate Class I: ±32 Ungulate Class II: ±33 Ungulate Class III: ±13 (Humphreys & Thackeray 1983: 268-269, Tables 79 & 80).	Tortoise: 0 Hare: ±18 Dassie:±6 (Humphreys & Thackeray 1983: 268-239, Tables 79 & 80).	None found
Little Witkrans 27°39'40"S; 24°36'45"E Date: 7500-1400BP (Humphreys & Thackeray 1983: 173-175).	Ungulate Class I: 0 Ungulate Class II: 0 Ungulate Class III: 0 (Humphreys & Thackeray 1983: 268-269, Tables 79 & 80).	None found	None found

Table 2.3: A summary of herbivorous fauna and flora recovered from archaeological sites along the Riet River.

Site name, location, date & reference	Number of larger fauna	Number of small fauna	Evidence of flora
RIET RIVER SITES **Kalkfontein Dam:** 29°30'54.52"S, 25°15'57.52"E **Riet and Vaal River Confluence:** 28°59'58.59"S, 23°53'15.05"E Pramberg ODF 1 Khartoum 1			
Pramberg 29°14'38"S, 24°45'15"E (Brink *et al.* 1992: 54)	Ungulate Class I*: ± Ungulate Class II*: ± Ungulate Class III*: ± (Brink *et al.* 1992: 55, Table 2)		None
OFD 1 29°18'59.01"S, 24°55'32.30"E (Google Earth)	Ungulate Class I*: 1 Ungulate Class II*: ±7 Ungulate Class III*: ±5 (Maggs 1971: 62, Table 5)	Tortoise: ±4 Fish: 1 Hare: 0 Dassie: 0 Freshwater mussel: ±6 Lizard: ±2 Frog: 1 Medium bird: 1 (Maggs 1971:62, Table 5)	None
Khartoum 1 29°16,4'16.72"S, 24°40'12.90"E (Google Earth)	Ungulate Class I*: ±2 Ungulate Class II*: ±4 Ungulate Class III*: ±2 (Humphreys 1972: 151)	Tortoise: 1 Fish: 0 Hare: 0 Dassie: 0 Freshwater mussel: 1 Lizard: 0 Frog: 0 Medium bird: 0 (Humphreys 1972: 151)	None

*Ungulate Class I: Steenbok, duiker and klipspringer

**Ungulate Class II: Sheep, goat and springbok.

***Ungulate Class III: Wildebeest, hartebeest, zebra and cattle.

Plants as a Food Component

The seven Northern Cape sites excavated by Humphreys & Thackeray (1983) did not have plant remains. This is expected as it is known that plants do not usually preserve well and are often absent in archaeological sites. Similarly, the limited excavations undertaken to date at Riet River Type-R settlements of the Northern Cape have not yielded any plant remains (Maggs 1971; Humphreys 1972). This is by no means an indication of the absence of plants in the inhabitants' diets. Studies on modern day Ju/wasi and Gw/i of the Kalahari show that vegetables contributed as much as 67% of hunter-gatherer daily diet (Cordain *et al.* 2002), and 80% of the total diet (Lee 1993; MacDowell 1995), including roots, berries and melons, which may make up to 100% of the diet (Silberbauer 1981). While 35 species are collected regularly, some species are consumed occasionally (Silberbauer 1981). This, however, depends on the time of the year. In the 1950s Elizabeth Marshall Thomas spent four years studying the Ju/wasi. She notes the importance of "veld food" in the diets of this hunter-gatherer group (Marshall Thomas 1969: 101). Amongst these were plants similar to onions, leafy green vegetables and pea pods (Marshall-Thomas 1969). One of the most valued vegetables of the Kalahari was the tsama melon, its multifaceted purpose serving more than food, as Marshall-Thomas (1969: 103) notes during her gathering trip with the Bushmen women during a winter morning:

Melons are eaten as both food and water, their pulp is added to meat which needs liquid for boiling, their seeds are roasted and eaten or ground into powder and used as flour, their rinds serve as mixing-bowls, as containers for small, loose objects...and all this amounts to a serious loss for Bushmen when melons rot or dry.

Association of Riet River Burials with Type-R Complex

The Riet River burials, especially those recovered on the eastern portion of the river between Kalkfontein Dam and Jacobsdal, come from the same area as the Type-R settlements. In some cases, there is a clear association between graves and settlement units. Three of the graves excavated by William Fowler lay within stone-walled structures. Van Riet Lowe (1929, Plate 37) shows a number of graves along the Riet River, all near to stone ruins (Maggs 1971, Fig. 2.2). At OFD 1, a burial area containing about 20 stone mounds, most of which are likely to be graves, lay slightly to the south of the settlement units, on the river terrace (Humphreys & Maggs 1970; Maggs 1971). Maggs points out that river terraces are usually the nearest places to the stone-walled ruins where the soil would have been deep enough to dig graves. Furthermore, he notes that the extensive use of stone in the graves may indicate that the

society regularly built with that material. Both Humphreys (1972) and Maggs (1971) refer to the burials as having a distinct tradition. The features of this tradition include the presence of grave goods, the placement of stones for a cairn, a grave shaft filled with stones and the tendency for individuals to be buried in the flexed position (Humphreys 1972). The similar range of objects including Iron Age copper ornaments and pottery that is clearly distinct has strengthened this belief. Further, the geographical overlap of the burials and settlements, and the discovery of archaeological artefacts on some of the farms on which the settlements are found makes the observation worth looking into further.

Morris (1992) warns against making the assumption that all burials found along the Riet River are associated with Type-R settlements. This is illustrated by the radiocarbon date of more than 3000 BP from a skeleton recovered in Weltevreden (Morris 1992) – a much earlier date than most Type-R evidence. Morris (1992) groups Riet River burials into those associated with, and those that cannot be clearly associated with Type-R settlements. His categorization is based on the distance of the burials from the settlements, the association of grave goods from both the burials and settlements, and how closely the graves cluster. Table 2.4 shows the same list, with some modifications for the purposes of this study. The same categorization was done for this study, based on association of a given skeleton with domesticated animal bones, the presence of copper staining and/or ornaments in the burial as well as the distance of the burials from the settlements. With the exception of 7 individuals, the present study and Morris (1992) use the same individuals, and contrary to the latter study, MMK 213 has been classified as being associated with the Type-R settlements (Table 2.4). The association is based on the copper staining that was found on the right mastoid, zygomatic arch, right mandibular ramus, as well as the right distal radius and ulna of this individual upon inspection. In a later chapter, isotopic values for the burials that are clearly associated with the settlements will be compared with those that are less clearly associated, to find out whether there is any difference between the two groups.

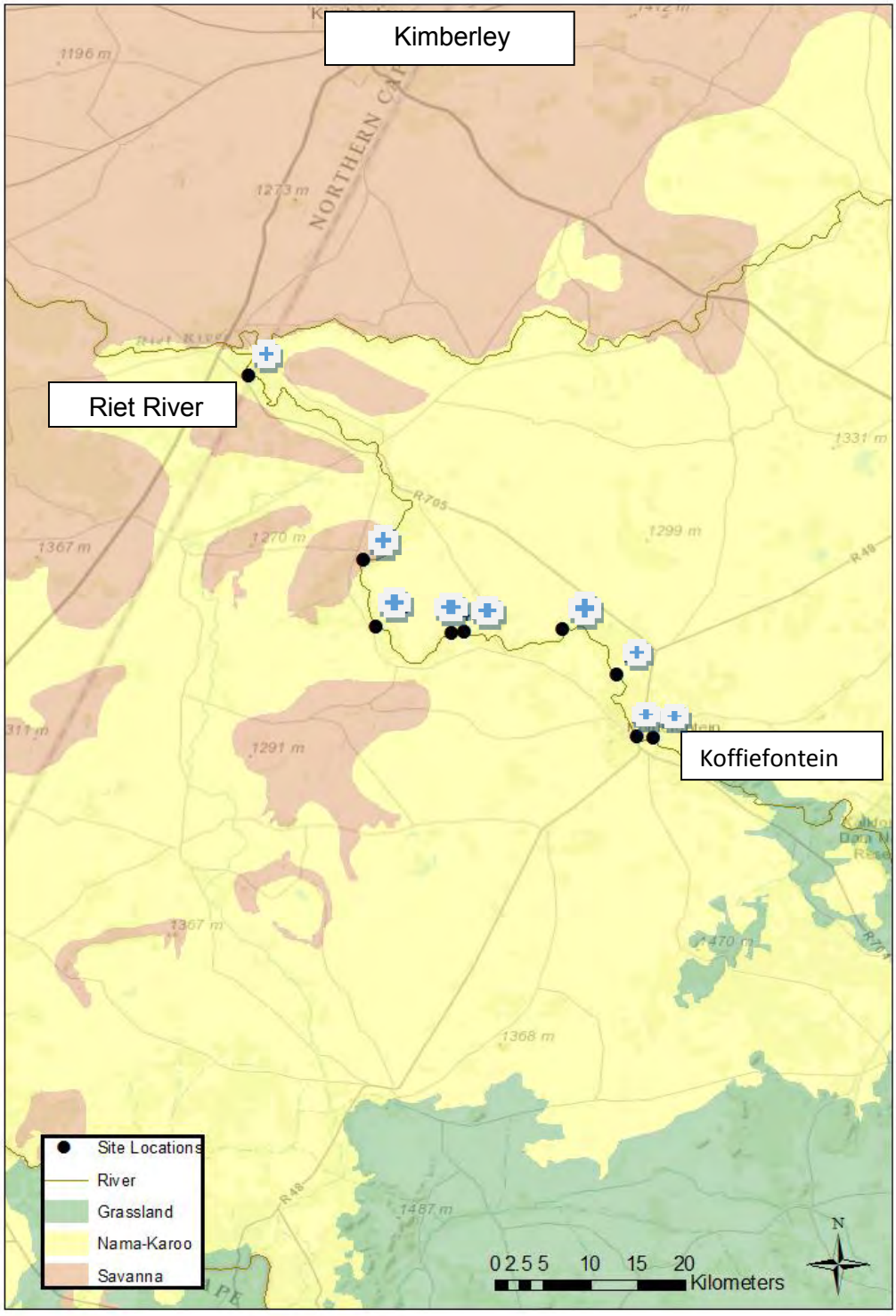

Figure 2.2: A graphical illustration of the approximate location of nine of the Riet River burials. Adapted from Van Riet Lowe (1931). Precise locations were not recorded.

Table 2.4: A list of skeletons that a) are clearly associated with, and b) are not clearly associated with Type-R settlements. Figures in italics refer to individuals who are part of the present study but were not included in Morris (1992). In this study, MMK 213 is considered to be clearly associated with Type-R.

a) Clear Association	b) Unclear Association
MMK 194	*MMK 173*
MMK 195	MMK 189
MMK 202	MMK 190
MMK 203	MMK 192
MMK 211	MMK 198
MMK 213	MMK 201
MMK 223	MMK 204
MMK 228	MMK 206
MMK 229	MMK 208
MMK 235	MMK 209
MMK 236	MMK 212
MMK 244	MMK 214
MMK 249	MMK 217
MMK 277	MMK 218
MMK 287	MMK 219
MMK 296	MMK 220
MMK 316	MMK 221
MMK 317	MMK 222
MMK 321	MMK 224
MMK 329	MMK 230a
MMK 330	MMK 230
MMK 335	MMK 231
A 268	MMK 237
A 269	MMK 238
A 330	MMK 239
A 331	MMK 245
A 332	MMK 246
A 333	MMK 247
A 334	MMK 248
	MMK 250
	MMK 252
	MMK 255
	MMK 272
	MMK 281

a) Clear Association	b) Unclear Association
	MMK 286
	MMK 311
	MMK 322
	MMK 324
	MMK 325
	MMK 332
	MMK 334
	A 123
	A 240
	A 326
	A 327
	A 2799

Conclusion

This chapter has reviewed the relevant archaeological and historical literature on the Northern Cape and Riet River Area, its inhabitants and their relationships to give a context for the interpretation of the isotope results. The next chapter discusses the history of dietary reconstruction using light stable isotope chemistry.

Chapter Three:

Background to the use of Light Stable Isotopes as Palaeodietary Indicators on Archaeological Material

In this chapter, a review of the history of paleodiet reconstruction using light stable isotope analysis is presented. Following this is a discussion of the use of (particularly) three specific stable isotopes (carbon, nitrogen and oxygen) on bone and teeth for the purpose of addressing archaeological enquiries. The chapter ends with an overview of enamel and bone formation and turnover rates.

Use of Carbon and Nitrogen for Paleodietary Reconstruction

Light stable isotope analysis was first used as a geochemical technique (Schoeninger & Moore 1992). After the discovery of its value in archaeology, it was used as a tool in paleodietary reconstruction for archaeological scientists (Vogel & Van der Merwe 1977; Vogel 1978; Van der Merwe 1982; Schoeninger & DeNiro 1983; Schoeninger *et al.* 1983; Sealy & Van der Merwe 1985; Sealy *et al.* 1986; Sealy *et al.* 1987; Sealy & Van der Merwe 1988; Sealy 1989; Sealy *et al.* 2000; Sealy 2006; Sealy 2010; France & Owsley 2014). Decades after its development into a useful technique in answering archaeological questions, it is now an invaluable tool for academia across innumerable disciplines ranging from geology to forensics. In the archaeological discipline, and specific to this thesis, light stable isotope analysis of carbon and nitrogen in bone collagen is valuable in reconstructing the lifetime dietary averages in archaeological skeletons. Prior to the use of isotope analysis, archaeologists relied solely on physical food wastes to shed light on the dietary and subsistence patterns of past individuals and/or human populations. Though isotope chemistry has contributed greatly since its inception, physical food waste still plays an in important role in archaeological enquiries. Contemporary research includes the use of food residues from archaeological artefacts found on sites, such as pottery and stone tools (Pearsall *et al.* 2004; Boyd *et al.* 2008), which, when used with isotope analysis, provides a more reliable means by which to decipher the complex web of prehistoric social and economic human interaction.

The basis of stable carbon isotope analysis lies in the disparity in photosynthetic pathways that plants follow which, in turn, produces characteristic carbon isotope values. Plants use three distinct photosynthetic pathways, the Calvin-Benson (C_3) cycle, the Hatch-Slack (C_4) cycle, and the Crassulacean Acid Metabolism (CAM) cycle. Each pathway metabolises atmospheric

carbon dioxide during the photosynthetic process in a distinct way and therefore yields varying carbon isotope fractionations (Van der Merwe 1982; O'Leary 1988; Leatherdale 2013). Following the discovery of the similarity of isotopic values of consumers to those of the food they eat, researchers have been given a tool that allows them to enquire about past life ways.

Calvin-Benson and Hatch-Slack Photosynthetic Cycles and their Effect on the Carbon Isotope Composition of Plants

Many chemical elements are known to exist in more than one isotopic form. Carbon exists as ^{12}C, ^{13}C and the radioactively unstable ^{14}C (Hoef 1980; Van der Merwe 1982). Consequently, this study focuses only on the two stable forms of carbon. Isotopes are a result of differences in neutron numbers within the nucleus of each isotope, resulting in distinct atomic mass in each carbon isotope (O'Nier & Gulbransen 1939). As a result of the number of the equality in the number of protons, the isotopes of a given element will have the same atomic number (O'Nier & Gulbransen 1939; Schoeninger & Moore 1992). Similarly, because of the equality in the electron numbers, the isotopes of a given element will have similar chemical reactions. The distinctness in atomic weight as a result of differences in neutron numbers causes discrepancies in reaction rates between the isotopes of an element (Schoeninger & Moore 1992; Leatherdale 2013). The relative differences in mass between reactive species determine the magnitude of the effect, small molecules of the lighter element having the greatest effect.

Fractionation, the change in isotope ratios as a result of different rates at which isotopes undergo chemical reactions, differs from one photosynthetic pathway to the next. During the Calvin-Benson cycle (also known as the C_3 pathway), carbon from atmospheric carbon dioxide is fixed with ribulose biphosphate (RuBP) to form two phosphoglycerate molecules within the leaf mesophyll cells of shrubs, trees and grasses of temperate environments (Ehleringer & Cerling 2002; Tykot 2004). The ^{13}C content of atmospheric carbon dioxide is 7 parts per thousand, or per mille (the symbol ‰ is used hereafter) lower than that of the Peedee Belemnite reference standard such that the deviation from the standard is expressed as -7‰ (Friedli *et al.*1986; Vogel & Van der Merwe 1977). The C_3 pathway depletes the relative ^{13}C abundance in plant tissues by an additional 19‰. Consequently, C_3 plants have a mean $\delta^{13}C$ value of -27.1±2.0‰, with a range of -22‰ to -30‰.

In the Hatch-Slack cycle (or the C_4 pathway) plants adjust themselves structurally and biochemically. Phosphoenolpyruvate carboxylase (PEPCase) is used to concentrate atmospheric carbon dioxide around Rubisco, the enzyme involved in carbon fixation (Sage

2004). Plants that use the C_4 pathway include grasses indigenous to arid and hot environments. From carbon fixation, the four-carbon containing compound, dicarboxylic acid, is produced (Sage 2004). Next, the dicarboxylic acid is transferred into bundle sheath cells where carbon dioxide is released by decarboxylation (Sage 2004). The C_4 anatomical arrangement allows the plants to concentrate carbon dioxide in the bundle sheath cells. Consequently, Rubisco has a high concentration of carbon dioxide from which to work. C_4 plants have heavier mean $\delta^{13}C$ of -13.1±1.2‰ as a result of less discrimination against the heavier ^{13}C isotope, and carbon isotope values range between -10‰ to -14‰ (Cerling *et al.* 1997; Katzenberg 1989; Pate 1994). Crassulacean Acid Metabolism (CAM pathway) is used by plants that inhabit arid environments. In the CAM photosynthetic pathway, carbon fixation occurs at night. Thereafter, malic acid is produced, which is temporarily stored and then used in the Calvin cycle during the day time (Keeley 1998).

The ^{13}C content of carbon dioxide is established using a high precision mass spectrometer for measuring the ratio, R, where:

$$R = {}^{13}CO_2/{}^{12}CO_2$$

The R values are converted to $\delta^{13}C$ values such that:

$$\delta^{13}C = \left[\frac{R\ (sample)}{R\ (PDB\ standard)} - 1\right] * 1000‰$$

Isotopes in Animals

The proportion of heavier isotopes in the bodies of higher organisms increases with each successive trophic level. The bone collagen of herbivores is enriched by about 6.1‰ in ^{13}C relative to the value of the plant (Vogel 1978). Caut *et al.* (2009) report values of up to 9.2‰ for nitrogen discrimination factors ($\Delta^{15}N$). The carbon isotope composition of the bone tissue of herbivores is based on the photosynthetic pathway of the plant consumed. Similarly, the carbon isotope signature laid down in the bone tissue of carnivores after meat consumption is based on the isotopic signature of the food they eat, herbivores. Carnivores have more positive $\delta^{13}C$ and $\delta^{15}N$ values than herbivores, but the diet to tissue fractionation is smaller. In humans, collagen has $\delta^{13}C$ enrichment factor of +5.1‰ (Lee-Thorp *et al.* 1989). The implication of this value places the average $\delta^{13}C$ value for an individual who consumes a predominantly C_3 diet in the range of -16.9‰ to -24.9, while an individual consuming a C_4 dominant diet will have a range of -4.9‰ to -8.9‰. Lee-Thorp *et al.* (1989) reports an enrichment value of +9.6‰ for tooth enamel

in humans. This means that, for an individual whose diet is C_3 dominant, the range of $\delta^{13}C$ values will be -11.5‰ to -20.4‰, and -0.4‰ to -4.4‰ for a C_4 based diet. It should be noted that the negative end of the C_3 range applies only in dense forests, and is therefore not relevant to this study.

River food webs are complex, both spatially and temporally. The drainage network system of freshwaters contains a series of living and non-living organic matter (Finlay & Kendall 2007). These are available for stream consumers to use, depending on factors such as stream size as well as the varied water linage system which creates a complex series of interactions with the food web (Finlay & Kendall 2007). Freshwater photosynthetic organisms are known to use either the C_3 or CAM pathways. Boutton (1991) reports a $\delta^{13}C$ range of -42‰ to -26‰ for lake planktons, and -30‰ to -25‰ for river planktons. A $\delta^{13}C$ range of -47‰ to -8‰ is given for algae and aquatic plants, and -15‰ to 20‰ for $\delta^{15}N$ (Finlay & Kendall 2007). A carbon and nitrogen analysis on 157 fish bone from 15 archaeological sites in Belgium produced a $\delta^{13}C$ range of -28.2‰ to -20.2‰ for freshwater fish (Fuller *et al.* 2012), and a mean of 11.5‰ for $\delta^{15}N$ from Southwestern Alaskan freshwater fish (Nash *et al.* 2012).

It is the fundamental principles mentioned above that have allowed archaeologists to trace prehistoric diet and thus understand the economic dynamics of past people

Nitrogen Chemistry of Bone Tissue

The element nitrogen occurs in two isotopic forms, the more abundant and lighter ^{14}N, and the heavier and less common ^{15}N, the latter contributing 0.366 atom % of atmospheric nitrogen (Delwiche & Steyn 1970; Handley & Raven 1992). The standard for nitrogen isotope measurements is atmospheric nitrogen gas. The majority of organic material contains more ^{15}N than the standard. Like ^{13}C, the ^{15}N is expressed in delta notation relative to the standard. The relative ^{15}N content is expressed as follows:

$$\delta^{15}N = \left[\frac{R\ (sample)}{R\ (AIR\ standard)} - 1\right] * 1000$$

Much of the variation in nitrogen isotope ratios in terrestrial foodwebs derives from processes of nitrogen fixation and nitrogen cycling in soils. The $\delta^{15}N$ of soil originates from a complex series of processes that involves nitrogen input, as well as conversion between various forms of nitrogen such as nitrification and denitrification (Evans 2007; Sheng *et al.* 2014). One source of nitrogen input into soil is nitrogen fixation, the conversion of inert atmospheric nitrogen gas into

plant usable compounds by bacteria (Postgate 1998). It has been previously suggested that the $\delta^{15}N$ of nitrogen-fixing organisms is similar to that of the atmospheric source because fractionation during nitrogen fixation was thought to be absent (Evans 2007). However, a fractionation factor of 0‰ to 3‰ has since been observed during nitrogen fixation (Evans 2007). This implies that nitrogen-fixing organisms will have $\delta^{15}N$ values of between 0‰ and 3‰ (Fry 1991).

Nitrogen processes within the soil are capable of causing remarkable nitrogen isotope effects, as well as make it difficult to estimate discrimination factors (Evans 2007; Sheng *et al.* 2014). The $\delta^{15}N$ of plants are mainly affected by the source of nitrogen, i.e. the forms of nitrogen in the soil that are used by the plants (Sheng *et al.* 2014). Other factors that have an influence on plant $\delta^{15}N$ values are the mean annual precipitation (MAP) and mean annual temperature (MAT). Further, the $\delta^{15}N$ values are known to vary depending on the plant part, the type of plant, and the season (Handley *et al.* 1999).

In some environments, terrestrial plants (and animals) display substantial enrichment in ^{15}N (Heaton *et al.* 1986; Sealy *et al.* 1987). It is now known that elevated ^{15}N values in plants and animals are a phenomenon that occurs in arid areas (Murphy & Bowman 2006, 2009). This is, therefore, likely to be true of the Northern Cape.

In animals (including humans), the relative ^{15}N content is useful as a trophic level indicator (Schoeninger *et al.* 1983; Hedges & Reynard 2007). Bone collagen $\delta^{15}N$ values have been shown to increase (i.e. are enriched in ^{15}N) by an average of 3-4‰ for each successive trophic level (Schoeninger *et al.* 1983; Schoeninger & DeNiro 1984), although there may be more variation in some cases (Hedges & Reynard 2007; Caut et al. 2009). Since nitrogen is found in protein molecules, but not in fats or carbohydrates, $\delta^{15}N$ values reflect the protein foods consumed (Schoeninger & DeNiro 1984). One problem with nitrogen isotopes is that, because of the high degree of variation that may occur in different environments, $\delta^{15}N$ values for the different types of foods that may be consumed should be determined for each food-web studied. This is rarely done. In addition, the precise degree of ^{15}N enrichment in human tissues compared with diet is not well understood. Thus, although it is possible to use $\delta^{15}N$ measurements to make general (usually relative) inferences about the nature of the diet, these should not be over-interpreted (Hedges & Reynard 2007).

Oxygen Chemistry

The oxygen source for the body of a living organism is food consumed, drinking water, and oxygen from the atmosphere (Sponheimer & Lee-Thorp 1999). In humans, as in other mammals, the oxygen isotope composition of tooth enamel is dependent mainly on drinking water, with a small contribution from food (Longinelli 1984; Kohn *et al.* 1996; Sponheimer & Lee-Thorp 1999; White *et al.* 1998). The oxygen isotope composition, in turn, is largely affected by diet, physiology and climate (Sponheimer & Lee-Thorp 1999). Warmer periods are reflected by higher $\delta^{18}O$ values, and the opposite is true for colder periods (Balasse *et al.* 2002). The $\delta^{18}O$ values are reported in parts per mille, relative to the PDB standard:

$$\delta^{18}O = \left[\frac{R\,(sample)}{R\,(\,PDB\ standard)} - 1\right] * 1000‰$$

The use of both $\delta^{18}O$ and $\delta^{13}C$ broadens the scope of questions that may be raised concerning prehistoric existence, making the combination of several elemental chemistries valuable for researchers.

Bone Collagen and Tooth Enamel Formation and Turnover

The Process of Bone Formation: The Chemical Make-Up of Bone

Bone consists of apatite (inorganic calcium phosphate) precipitated in a matrix of organic collagen (Pate 1994). Further, the composition of bone considerably depends on the type of bone and age (Pate 1994). Cortical bone is 9% water, 22% organic and 69% inorganic material (Suchanek & Yoshimura 1998). While 90% of the organic fraction of cortical bone is made up of collagen, the other 10% is non-collagenous protein (such as glycoproteins, proteoglycans and phosphoproteins), fats, enzymes, carbohydrates and hormones (Pate 1994). A molecule of collagen consists of polypeptide chains in triple helix form. Amino acids are the structural components of collagen fibril (Pate 1994).

During life, once bone has formed it “remodels” or “turns over”: a process in which old bone tissue is replaced with new bone tissue through bone resorption by osteoclasts, and bone formation by osteoblasts.This results in the obliteration of old and subsequent formation of new bone, in microscopic pockets called bone structural units, or BSU (Pate 1994).

Bone formation is, or osteogenesis, is a process that involves two phases, namely the intramembraneous and endochondal ossification. Intramembraneous ossification (the direct

mineralization of highly vascular connective tissue) occurs during the formation of flat bones such as the skull, mandible and maxilla, and clavicle (Kini & Nandeesh 2012). The mesenchymal stem cells (MSC), involved in the creation of bone tissue, initiate the process at the centre of ossification. At the centre, the mesenchymal cells multiply and congregate around the capillary network (Kini & Nandeesh 2012). The cells and vessels are surrounded and enmeshed by an amorphous ground substance with collagen fibres and the mesenchymal cells differentiate into osteoblasts, forming an aggregate, in whose centre the osteoid is created (Kini & Nandeesh 2012). The osteoblasts, which produced the bone matrix, become surrounded by collagen fibres, and then become osteocytes. A nidus containing mineralized osteoid with osteocytes as well as a lining of active osteoblasts results from the mineralization. As more osteoblasts are enmeshed, the trabeculae thicken, and the vascular spaces are narrowed (Kini & Nandeesh 2012). The process slows down at the area that continues as cancellous bone, and hemopoietic tissue fills the spaces. At this time the periosteum (a layer of vascular connective tissues that surround the bone except at the joints) is formed, and the bone continues to grow on the trabeculae surface (Kini & Nandeesh 2012).The growth results in woven bone, which his replaced by lamellar bone.

Endochondral ossification takes place in most of the rest of the bones, including the long bones, and involves five steps, namely the development of a cartilage model, the growth of the cartilage model, development of the primary centre of ossification, development of the secondary centre of ossification, and the formation of the articular cartilage and epiphyseal plate. During fetal development, the long bones each begin as a rod of hyaline cartilage, and are covered by a highly vascular condensed mesenchyme or perichondrium. These mesenchymes resemble those that surround the intramembraneous ossification centres (Kini & Nandeesh 2012). Chondrocyte cell division extends the length of the cartilage model, and the extracellular matrix is secreted (Kini & Nandeesh 2012). As more of the matrix is secreted on the periphery of the cartilage surface, the cartilage model thickens. Simultaneous to this, chondroblasts develop on the perichondrium (Kini & Nandeesh 2012).

The primary ossification centre is the area where the first ossification occurs, at the centre of the bone shaft. It is followed by a series of processes including the formation of the periosteum, the bone collar, calcification of the matrix, invasion of the periosteal bud, and the formation of trabeculae (Kini & Nandeesh 2012). A secondary ossification centre appears at the epiphyses of the long bone at about the period of child birth. Blood vessels and mesenchyme are carried through by the periosteal buds and the process that occurs is similar to that which takes place in

the primary ossification centre (Kini & Nandeesh 2012). The epiphyseal plate forms new cartilage, which is replaced by bone. This causes longitudinal growth of the bone, and when the cartilage is replaced by bone, growth stops (Kini & Nandeesh 2012).

Adult bones reportedly have a mean annual cortical remodelling percentage of 1.8% for the cranium, 2.9% for femora, 4.7% for ribs and 8.3% for vertebrae (Pate 1994). In a more detailed study, Hedges *et al.* (2007) have produced results on femoral turnover rates in males and females. The study indicates that in adult females, collagen turnover in the femoral mid-shaft decreases from 4% to 3% per year from the age of 20 to 80 years. In adult males, it is approximately 1.5% to 3% throughout this period. This means that different body tissues offer stable isotope information relevant to different periods of an individual's life.

Tooth Enamel

Hydroxyapatite (or bioapatite), the main component of enamel in teeth, is a calcium phosphate mineral that contains carbonate ions. Unlike bone, enamel is the most mineralized (96%) substance in the body, with 4% being water and protein (del Pilar Gutiérrez-Salazar & Reyes-Gasga 2003). The carbon component of carbonate ions is a useful indicator of dietary behaviour (Tieszen & Fagre 1993), and because of the resistance of tooth enamel to post-depositional degradation in archaeological contexts, it has become an increasingly valuable material in dietary reconstruction.

Enamel Formation

Enamel formation (or amelogenesis) is a four-stage process (presecretory, secretory, transition and maturation stages), which involves enamel depositional cells called ameloblasts. Ameloblasts are a constituent of the enamel organ, which comprises of the outer epithelial layer, the stellate reticulum, the stratum intermeduim, and the inner enamel epithelium (Bartlett 2013). In the presecretory stage, odontoblasts (dentin-producing cells) deposit predentin, first at the tip of the cusps and then continues to the cervical parts of the tooth (Bartlett 2013). Mineralization begins with predentin, which occurs below the site of what later becomes the dentin-enamel junction (DEJ) (Bartlett 2013). The mineralization results in a thickened dentin, as the process of mineralization continues towards what will become the pulp chamber. The mineralization is initiated by ameloblasts which begin by secreting enamel proteins (Nanci 2003).

During the secretory stage, the ameloblasts elongate into long columner cells with a Tomes' process at the distal end of each cell, nearest to the enamel matrix (Bartlett 2013). The Tomes'

process is important for the production of and organization of the enamel (Nanci 2003). Enamel matrix proteins are excreted by the secretory face of the Tomes' process, as well as the ameloblasts that are lined along that secretory face (Bartlett 2013). This results in the formation of enamel crystals, which grow between dentin crystals, and then elongate at the site of enamel protein secretion (Bartlett 2013). Simultaneous to the movement of the ameloblasts from the dentin surface, more enamel matrix is secreted to thicken the newly developed enamel layer (Bartlett 2013). The movement from the dentin surface is coupled with the secretion of four proteins by the ameloblasts into the enamel matrix, namely the amelogenin (AMELX), ameloblastin (AMBN), enamelin (ENAM), and matrix metalloproteinase-20 (MMP20) (Bartlett 2013). At the termination of the maturation stage, when the proteins have almost been removed, the enamel reaches its final hardened form. It is also at this point that ameloblasts begin their maturation phase (Nanci 2003).

During the transitional and maturation phase, the ameloblasts' Tomes' processes are withdrawn, the enamel surface is smoothed over with aprismatic enamel, followed by a transition into shorter maturation cells (Nanci 2003; Bartlett 2013). The enamel organ constituents, with the exception of the inner enamel epithelium, reorganize such that recognition of cell layers on an individual basis becomes impossible (Nanci 2003). Blood vessels run within these cells so that a papillary layer is formed (Nanci 2003). Upon enamel maturation, the papillary layer and inner enamel epithelium revert and become the reduced enamel epithelium (Nanci 2003). The epithelium becomes important for covering and protecting the enamel (Nanci 2003. Because tooth enamel does not turnover after formation, it reflects dietary consumption and climatic conditions during its formation (Balasse *et al.* 2002).The third molars are the last teeth to erupt during the life of a young adult. As a result, third molars draw interest for researchers as their isotope values most closely reflect the long-term average dietary intake of an adult individual (Pate 1994).

One of the key goals of this thesis is to understand the relationship between $\delta^{13}C$ values of bone collagen and tooth enamel. The study of the carbon isotope values from these two materials thus allows for this, as each reflects unique isotope signals.

Conclusion

In this chapter, the basic principles of light stable isotope analysis in paleodiet reconstruction were outlined. The factors influencing the distributions of the isotopes of carbon, nitrogen and oxygen were briefly described, focussing on aspects likely to be relevant to the current study.

The composition and formation of the body tissues of interest, bone and enamel, were briefly surveyed in order to understand their potential in paleodietary reconstruction. In the next chapter, the prehistory and environment of the Northern Cape is discussed, in order to provide a context for interpreting the isotope values of the individuals in this study.

Chapter Four:

Materials and Methods

This chapter describes the materials studied in this thesis and the analytical procedures used, especially the enamel and collagen preparation processes and the subsequent measurement of the stable isotope ratios.

These particular skeletons were chosen because of their geographical location, burial style (where recorded) and probable or possible association with Type-R archaeological sites (Appendix 1; Table 2.4). Some individuals can be confidently associated with the Type-R sites, such as those that were found in or near stone circles. Skeletons that do not show obvious association with the Type-R settlements but have grave goods that suggest it are also considered to be clearly associated. An example is the presence of grave goods such as copper artefacts (indicating contact with Iron Age farmers) and/or copper staining, and domestic animal bones.

The criteria used for the selection of the specimens are as follows: Adults and adolescents were preferred. Children who were young enough to breastfeed, and are therefore a trophic level higher than their mothers, were excluded since their isotope ratios are not directly comparable with those of adults. Skeletons that were sufficiently complete to provide both bone collagen and tooth enamel samples were preferred. However, this was not always possible as many skeletons were incomplete, so that in some cases only bone or enamel could be sampled. In a few instances, more than one individual was co-mingled, in which case sampling was carried out only if the different individuals could be clearly distinguished. Lastly, individuals whose bones were obviously poorly preserved and appeared to be held together by being heavily varnished were excluded.

Sample Collection

A small fragment of bone was taken from each specimen for collagen extraction and isotopic analysis. In most cases, the skeletal elements sampled were ribs. Whenever possible, fragments of rib bone (< 1 cm in length) were collected from ribs that were already damaged, in order to minimize damage to the collection. If ribs were not present, a small bone sample was removed from another skeletal element, once again, if possible, from an already damaged margin.

The third molar was preferred for enamel sampling as this is the last tooth to form, and therefore provides the closest approximation to an adult diet. In the absence of a third molar, the second

molar was sampled. For one individual (MMK 317), both the third molar and second premolar were sampled.

Enamel was removed using a Dremel Moto-Tool with a 0.5mm diamond tipped drill bit. For each tooth, the area to be sampled was cleaned by gently running the Dremel over the surface before the sample was collected in order to remove any surface contamination. Samples were taken by drilling along the vertical height of each tooth crown on either the lingual (tongue) or buccal (cheek) surface, from the occlusal surface to the cementum-enamel junction. This ensured that the enamel powder obtained would provide an average of each individual's diet over the period of formation of the tooth.

Mandibular teeth were preferred for sampling as it is more difficult to sample maxillary teeth in position in the cranium: the vibration of the drill tends to shake free sand and other particles that can contaminate the enamel samples. In some cases, where only maxillary teeth were present, drilling was avoided and a small fragment of enamel was taken instead, to avoid contamination. Side-cutters were used when necessary to remove small enamel fragments from already fractured teeth, avoiding damage to the whole tooth. Unfortunately, some specimens had very heavily worn teeth with large areas of dentine exposed and little or no enamel remaining. Dentine is an unwanted potential contaminant. Its yellow or sometimes brown colour distinguishes it from the white enamel, and thus assists one in sampling only the material of interest. The enamel powders were collected on clean laboratory weighing paper prior to being transferred to plastic snap-top 1.5ml centrifuge tubes for storage.

Laboratory Procedures

Bone Collagen Extraction

All bone samples were processed according to standard methods used in the UCT Archaeometry Laboratory, and described in Sealy *et al.* (2014), with some modifications. The surface of each bone sample was cleaned by sanding lightly with fine-grained sandpaper. Many bones appeared to have been coated with glue or varnish, so in all cases, samples were soaked in acetone to try to remove this contamination. For most samples, the acetone did not visibly discolour, but for some it did. In these cases, the acetone was replaced until no further discolouration was observed. Following this, each bone sample was dried, weighed, placed in a No. 8, 25ml Poly Top Glass vial and treated with approximately 20ml of 0.1M hydrochloric acid to remove the hydroxyapatite (Ambrose 1990). The samples were left in the hydrochloric acid at room

temperature, with a daily replacement of the acid until each bone had yielded a pseudomorph, i.e. it became translucent and flexible (rubbery) but retained the size and shape of the original bone fragment. At this stage, the mineral component of the bone has dissolved away, but the structural integrity of the pseudomorph indicates the presence of well-preserved collagen.

The decalcified samples were then placed in 0.1M sodium hydroxide solution overnight to remove base-soluble contaminants such as humic acids (Ambrose 1990). The samples were then placed in distilled water, the water replaced every day for several days in order to neutralize the pH. Finally, the collagen was freeze-dried. The mass of the collagen was noted to calculate the collagen yield. Approximately 0.5mg of collagen was weighed into a tin cup which was then folded to exclude air. The samples were placed in an automated Thermo Finnigan Flash EA 1112 series elemental analyzer. The samples were combusted at 1020ºC to produce CO_2 (g) and N_2 (g). Using a Conflo III gas control unit, the gases were purified before their introduction into the ThermoElectron Delta Plus XP isotope ratio mass spectrometer. Helium was used as the carrier gas. Isotope values were reported in parts per thousand (‰) relative to the PDB standard for carbon and AIR (atmospheric nitrogen) for nitrogen.

Tooth Enamel

The tooth enamel purification process was performed according to Lee-Thorp *et al.* (1997), with adjustments. Enamel samples that were in chunks were crushed into powder using a pestle and mortar. Each powdered enamel sample was placed in a 1.5ml centrifuge tube, which was then filled with 50% sodium hypochlorite solution to eliminate organic material. The samples were shaken every 15 minutes for 45 minutes. The samples were then centrifuged in a high speed centrifuge to separate the sodium hypochlorite and enamel powder. The sodium hypochlorite was poured off and the samples were rinsed three times with distilled water to achieve neutrality. Following this, 1.5ml of 0.1M acetic acid was added to the powered samples and left to react for about ten minutes, shaking at the beginning and end of the 10 minutes to remove soluble diagenetic carbonates. The samples were returned to a high speed centrifuge to separate the acid and powders. The powders were rinsed three times with distilled water, then freeze-dried.

Approximately 2mg of pre-treated powdered enamel were placed into a 12ml borosilicate glass tube. The glass tubes had been cleaned with phosphoric acid, rinsed three times with distilled water and dried before use. The tubes were capped with exetainer caps and placed in a Thermo-Finnigan II gas bench at 72ºC. The air in the tubes was removed by flushing with helium. Using a syringe, 0.03ml of 100% phosphoric acid was added to each sample through a septum. The

powder-phosphoric acid mixtures were permitted to react at a constant temperature of 72ºC for at least 3 hours, so that enamel carbonate was converted to CO_2 (g). This was passed through a Nafion Poraplot Q Gas Chromatographic column, then delivered to a Thermo Finnigan Delta Plus XP isotope ratio mass spectrometer, in which the carbon and oxygen isotope ratios were measured with Isodat software. The reference gas was commercially obtained 99.995% CO_2 (g). The results were calibrated using NBS 18, NBS 19 and Cavendish Marble. The results are reported in delta notion in parts per thousand (‰) relative to the Pee Dee Belemnite (PDB) standard.

Statistical Treatment of Results

Descriptive statistics (means and standard deviations for $\delta^{13}C$ and $\delta^{15}N$ values of collagen, and $\delta^{13}C$ of tooth enamel) were calculated using Excel. The T-Test was used to test for the significance (or lack thereof) of isotopic differences between different groups (e.g. males and females). Both the T-test for independent samples, and Mann-Whitney U Test were used for the $\delta^{13}C$ and $\delta^{15}N$ values for the population in this study.

Conclusion

The chapter described, in detail, the sample collection and laboratory preparation procedures for enamel and collagen samples. The results obtained from these procedures are described in the following chapter.

Chapter Five:

Results

This chapter reports the results of the carbon, nitrogen and oxygen isotope measurements of bone collagen and tooth enamel and gives an account of the relationship between the carbon isotope values of collagen and enamel. This relationship between the two body tissues is compared with the results of previously published studies (Warinner & Tuross 2009; Loftus and Sealy 2012; France & Owsley 2013).

Table 5.1 lists all the individuals included in this study, with $\delta^{13}C$, $\delta^{15}N$ and $\delta^{18}O$ values for bone collagen and tooth enamel, and information on the skeletal elements sampled. Table 5.2 shows the collagen yield, weight %C, weight %N and atomic C:N values, which are indicators of the quality of the extracted collagen. The range of values in this study is 24.1 to 46.8 for %C and 8.6 to 17.0 for %N. The range of C:N ratios is 3.2 to 4.0. Ambrose (1990) reported %N values of 4.8-17.3% in well-preserved bone collagen, and Van Klinken (1999) reported %N values in the range of 11-16% as acceptable. While Ambrose (1990) reported a %C range of 15.3 to 47%, Van Klinken (1999) reported a maximum %C value of only 35% as characteristic of intact collagen. Therefore, all the %C and %N values in this sample set are within the ranges specified by Ambrose (1990) and Van Klinken (1999). MMK 143 was cut through the cranium as though a post-mortem had been performed, and for this reason, although the samples taken were analysed, it will not be discussed further.

Atomic C:N ratios for all but two bone collagen samples in this study fall between 2.9 and 3.6, the range found by Van Klinken (1999) to characterise well-preserved collagen. The two exceptions are UCT 14075 (MMK 221) at 4 and UCT 14089 (MMK 255) at 3.7, respectively. Repeat measurements of C:N for UCT 14075 yielded values of 3.7 and 4.0. It should be noted that the %N (12.2) of this collagen sample is at the low end of the range in this sample set. This suggests degradation of the nitrogen within the collagen, which probably explains the high C:N ratio. For UCT 14089, the bone contained humic contaminants, indicated by a dark colour. This was validated by the high C:N ratio of 4.4 obtained from the first run. The collagen sample for this individual was then treated further with sodium hydroxide (NaOH), producing a lower C:N value of 3.7. The isotope results for these two samples should be treated with some reservations. Since the quality indicators (especially for UCT 14089) are close to the acceptable ranges, the $\delta^{13}C$ and $\delta^{15}N$ values will be considered below in conjunction with the rest of the

sample set. If, however, the results for these two samples are in any way unusual, they will not be used to draw conclusions about the group as a whole.

The $\delta^{13}C_{collagen}$ values range from -15.2 to -7.6‰, with a mean of -10.4±1.5‰ (n=68). The overall pattern in $\delta^{13}C$ ranges from enriched to depleted values. The spacing between the mean $\delta^{13}C$ values for C_3 and C_4 plants is about 14‰ while the range in this study is almost 8‰. This indicates a mixture of C_3 and C_4-based foods in the diets of these individuals. The range of $\delta^{13}C_{enamel}$ values is -8.6 to 0.56‰, with a mean of -3.5±1.9‰ (n=64). The total range of 9.6‰ indicates and supports the suggestion of a diverse food web for this population.

The $\delta^{15}N_{collagen}$ values range from 10.0 to 15.7‰, with a mean of 12.9±1.4‰ (n=68). The pattern for this population shows an overall enrichment of $\delta^{15}N_{collagen}$ values, with a range of almost 6‰, compared with the range of 8‰ for $\delta^{13}C_{collagen}$.The $\delta^{18}O_{enamel}$ values range from -2.4 to 5.4‰, with a mean of 0.4±1.4‰ (n=64). The pattern is one of overall enrichment of $\delta^{18}O_{enamel}$ values, with a range of 7.8‰. Fig. 5.1 shows a scattered distribution of $\delta^{18}O_{enamel}$ values relative to those of $\delta^{13}C_{enamel}$. The equation describing the regression of $\delta^{13}C_{enamel}$ on $\delta^{18}O_{enamel}$ is y=-0.1x – 0.1 with an R^2 value of 0.04. This means that only 4% of the value for $\delta^{18}O_{enamel}$ is determined by the $\delta^{13}C_{enamel}$ of that individual. There is no meaningful correlation between the two. Similarly, a plot of $\delta^{15}N_{collagen}$ against $\delta^{18}O_{enamel}$ shows a scattered distribution (Fig. 5.2).The equation describing the regression of this distribution is y=0.13-1.26 with an R^2 value of 0.014.

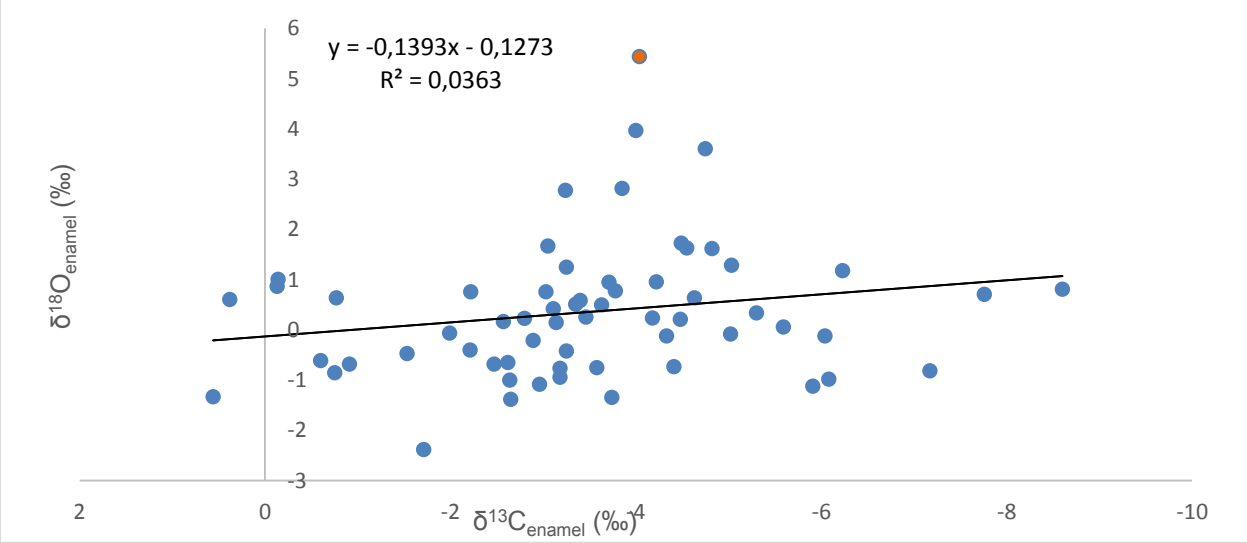

Figure 5.1: Scatter plot of $\delta^{13}C_{enamel}$ against $\delta^{18}O_{enamel}$ for all human skeletons.

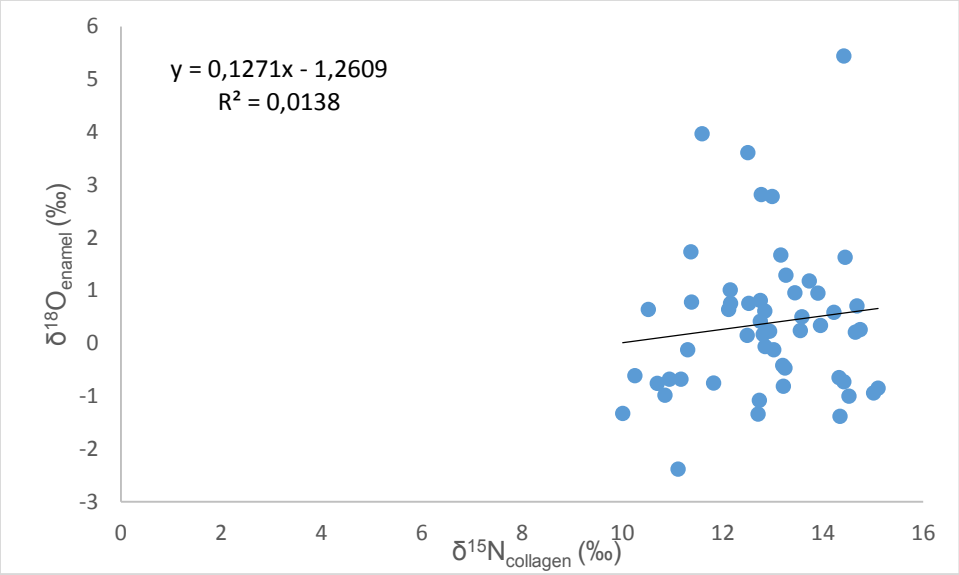

Figure 5.2: Scatter plot of $\delta^{15}N_{collagen}$ against $\delta^{18}O_{enamel}$ for all human skeletons.

$\delta^{13}C_{collagen}$ versus $\delta^{15}N_{collagen}$

Fig. 5.3 shows a scatter plot of $\delta^{13}C_{collagen}$ against $\delta^{15}N_{collagen}$. The overall distribution shows a loose cluster, with a regression equation of y= -0.2078x+10689 (R^2= 0.052). This indicates that only 5% of the value of $\delta^{15}N_{collagen}$ can be predicted from $\delta^{13}C_{collagen}$. The Spearman's Rank Co-efficient value of -0.23 indicates a weak negative correlation between $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$, which confirms the R-squared value. In Fig. 5.3, three points are worth mentioning and will be discussed in the following chapter. MMK 281 (UCT 14121) has a $\delta^{13}C_{collagen}$ value of -15.2‰ and $\delta^{15}N_{collagen}$ value of 15.7‰. This individual has the most negative $\delta^{13}C_{collagen}$ and the most positive $\delta^{15}N_{collagen}$ value in the data set and clearly lies outside the cluster formed by the other values. At the opposite end of the cluster, MMK 330 (UCT 14060) with a $\delta^{13}C_{collagen}$ value of -7.7‰ and $\delta^{15}N_{collagen}$ value of 10.3‰, and MMK 209 (UCT 14104) with a $\delta^{13}C_{collagen}$ value of -7.6‰ and $\delta^{15}N_{collagen}$ value of 10.0‰ have the most positive $\delta^{13}C_{collagen}$ and some of the lowest $\delta^{15}N_{collagen}$ values in the data set. Although these two points do not lie far from the bulk of the samples, they do make up the end points of the distribution.

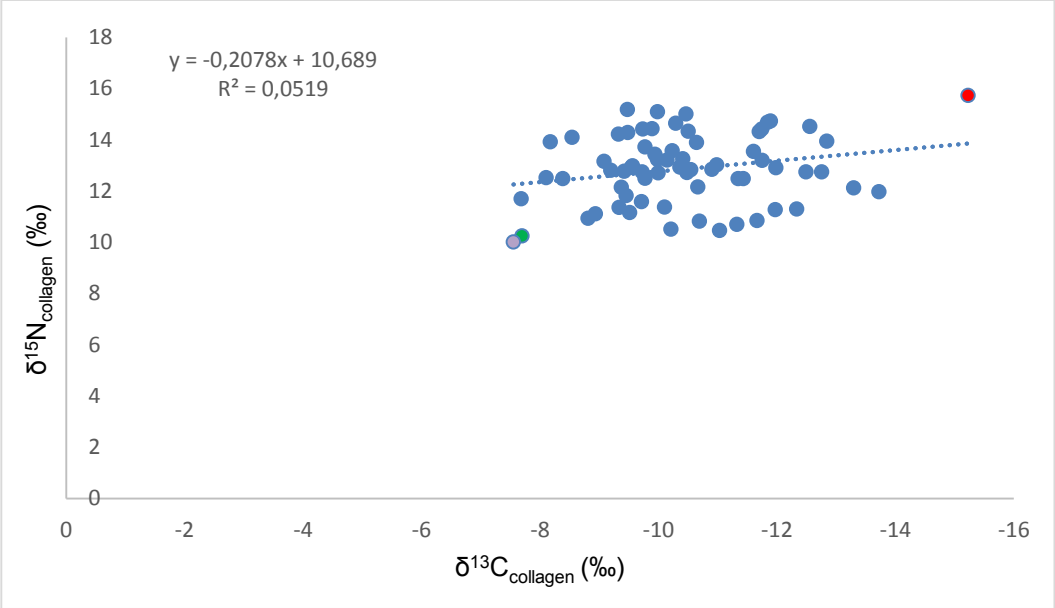

Figure 5.3: Scatter plot of $\delta^{13}C_{collagen}$ against $\delta^{15}N_{collagen}$ for all human skeletons. MMK 281 is shown in red, MMK 330 in green and MMK 209 in yellow.

$\delta^{13}C_{collagen}$ Compared with $\delta^{13}C_{enamel}$

A scatter plot of $\delta^{13}C_{collagen}$versus $\delta^{13}C_{enamel}$ (Fig. 5.4) shows a more diffuse scatter than Fig. 5.3. The range of values for $\delta^{13}C_{enamel}$ is wider than that for $\delta^{13}C_{collagen}$.The equation describing the regression of $\delta^{13}C_{enamel}$ on $\delta^{13}C_{collagen}$ is y=0.7x + 4.2 with an R^2 value of 0.24. That means that only 24% of the value for $\delta^{13}C_{enamel}$ is determined by the $\delta^{13}C_{collagen}$ of that individual. Removal of two points at the margin of the cluster (MMK 209 and 330) from the plot decreases the R^2 value to only 0.15.This is in contrast with the R^2 value of 0.62 reported by Loftus & Sealy (2012) for a similar regression of $\delta^{13}C_{enamel}$ on $\delta^{13}C_{collagen}$ for coastal South African hunter-gatherers, showing a substantially stronger relationship between the two body tissues. Such a weak relationship between the two tissues (Fig. 5.4) indicates that for this population, there appears to be considerable dietary heterogeneity in terms of carbon isotopes. The foods that provided the carbon from which tooth enamel was synthesised had a different carbon isotope composition from those that contributed to the formation of bone collagen. From our current understanding of the pathways of macronutrient assimilation into various body tissues, all dietary components, including fats and carbohydrates, contribute to the carbon in tooth enamel. Dietary protein is the primary source of carbon for bone collagen. This will be discussed in more detail in the forthcoming chapter, in the context of the human foodweb of the Northern Cape. The Pearson's

Rank Co-efficient value of 0.48 indicates a positive but weak correlation between the $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$, which validates the R-squared value.

Two of the three individuals whose $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values lie outside or on the edge of the cluster in Fig. 5.3 show the same pattern in Fig. 5.4. Enamel was not available for MMK 281. It is thus not apparent how this individual compares with the others. MMK 330 and MMK 209 not only have very enriched $\delta^{13}C_{collagen}$ values; their $\delta^{13}C_{enamel}$ are also amongst the most enriched in the sample set. The individuals are clearly different from the rest of the population. It appears that they had somewhat different diets, with a greater proportion of C_4-based foods than the rest of the population.

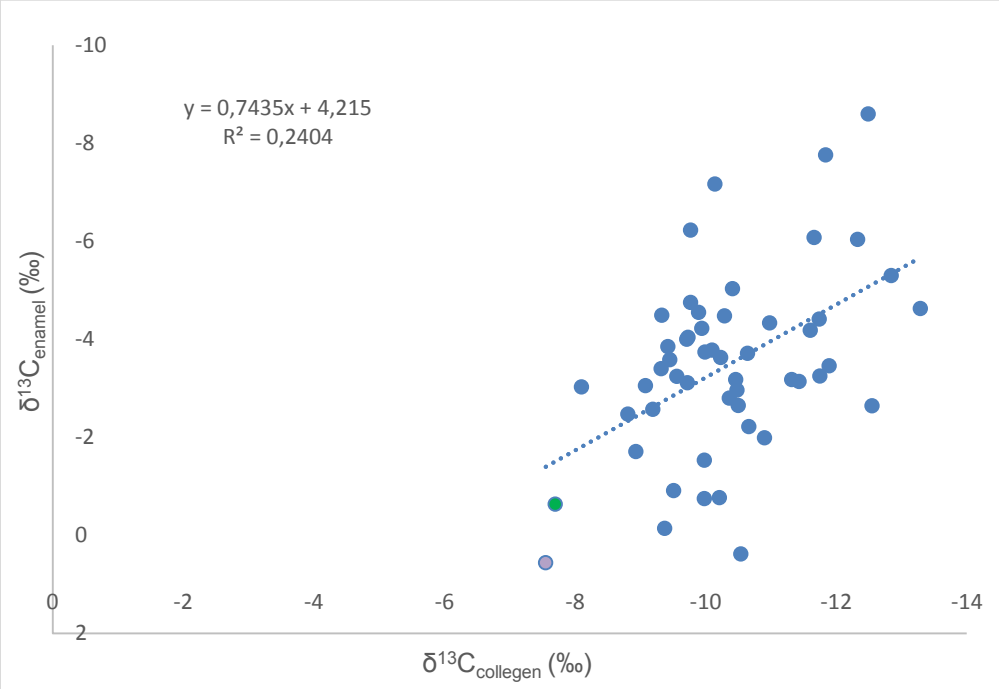

Figure 5.4: Scatter plot of $\delta^{13}C_{collagen}$ against $\delta^{13}C_{enamel}$ for all human skeletons with MMK 209 shown in yellow and MMK 330 in green.

Table 5.1: Details of skeletal elements sampled, $\delta^{13}C$ and $\delta^{15}N$ of bone collagen and $\delta^{13}C$ and $\delta^{18}O$ of tooth enamel for each human skeleton, together with estimated sex and information about grave goods, if present. Additional information on, and/or other grave goods noted during skeletal analysis by author is underlined. The letter F represents female, M male, J juvenile and U unknown.

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave goods
UCT 14056	MMK 277	Rib	-11.3	10.7	Right mand. M3	-3.2	0.8	F	O.E.S beads, Cu extinguishers, Cu staining around right mastoid area,
UCT 14057	MMK 211	None			Right Mand. M3	-4.4	-0.3	M	Grind-stone & sharpened slate slab
UCT 14058	MMK 252	Transverse process of lumbar vertebra	-11.7	14.4	M3 taken from loose tooth	-4.4	-0.7	M	String O.E.S beads, 1 cowrie shell
UCT 14059	MMK 248	Rib	-10.4	13.3	Left Mand. M3	-5.0	1.3	J	None
UCT 14060	MMK 330	Fibular shaft	-7.7	10.3	Left Max. M3	-0.6	-0.6	M	No grave goods
UCT 14061	MMK 329	Rib	-9.3	14.2	Mand. M3	-3.4	0.6	M	Cu plate pendant, O.E.S beads, ochre. Cu staining on skull
UCT 14062	MMK 249	Rib	-10.0	15.1	Right Max. P2 & Right Mand. M2	-0.8	-0.9	M	Grindstone, rimmed potsherd, piece of bored stone, circular scraper, Cu stains, sheep bone pendant
UCT 14063	MMK 228	Rib	-8.1	12.5	Right Mand. M3	-3.0	0.8	M	Blue glass beads, Cu stains on tibia & fibula.
UCT 14064	MMK 195	Rib	-9.7	12.8	Left Mand. M3	-3.1	0.4	M	None

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave Goods
UCT 14065	MMK 217	Rib	-9.4	12.8	Mand. M3	-3.9	2.8	F	O.E.S beads, pitted stone (small rounded natural pebble)
UCT 14066	MMK 218	Rib	-12.0	12.9	None			J	None
UCT 14067	MMK 219	Femoral Shaft	-12.0	11.3	None			U	brown & white stones
UCT 14068	MMK 223	Femoral Shaft	-9.5	12.9	None			J	None
UCT 14069	MMK 224B	Humeral Shaft	-11.7	10.9	Left Mand. M3	-6.1	2.1	F	O.E.S beads
UCT 14070	MMK 230	Rib	-7.7	11.7	None			J	None
UCT 14071	MMK 230a	Skull Bone	-10.0	13.2	Right Mand. M2	-1.5	-0.5	J	None
UCT 14072	MMK 229	Rib	-12.3	11.3	Left Mand. M3	-6.0	-0.1	M	O.E.S beads
UCT 14073	MMK 220	Rib	-13.3	12.1	Mand. M3	-4.6	0.6	M	None
UCT 14074	MMK 203	Rib	-11.0	13.0	Left Mand. M3	-4.3	-0.1	M	O.E.S beads
UCT 14075	MMK 221	Long Bone	-13.7	12.0	None			U	None
UCT 14076	MMK 222	Rib	-11.6	13.6	Left Mand. M2	-4.2	0.2	J	14 reddish brown beads, 2 bones
UCT 14077	MMK 204	Rib	-9.5	11.8	Left Max. M3	-3.6	-0.8	F	Wood ash
UCT 14078	MMK 190	Rib	-10.6	13.9	Right Mand. M3	-3.7	1.0	U	None
UCT 14079	MMK 192	None			Left Mand. M3	-3.3	1.3	U	O.E.S beads, chipped stone
UCT 14080	MMK 194	None			Left Max. M3	-0.1	1.1	U	None
UCT 14081	MMK 198	None			Right Mand. M3	-2.2	-0.4	U	None

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave Goods
UCT 14082	MMK 201	None			Right Mand. M3	-5.6	0.1	M	None
UCT 14083	MMK 202	Rib	-10.7	12.2	Right Mand. M3	-2.2	0.8	U	2 cattle incisors
UCT 14084	MMK 206	Rib	-9.8	12.5	Left Mand. M3	-4.8	3.6	F	None
UCT 14085	MMK 214	Rib	-9.5	15.2	None			J	None
UCT 14086	MMK 234	None			Left Mand. M3	-2.6	-0.7	U	Beads, leather bangle on arm
UCT 14087	MMK 239	Rib	-11.8	13.2	Left Mand. M3	-3.3	-0.4	U	O.E.S. pendant, 2 Oxystele shells
UCT 14088	MMK 250	Rib	-10.2	10.5	Right Mand. M3	-0.8	0.6	F	None
UCT 14089	MMK 255	Femoral Shaft	-9.4	12.2	Right Mand. M3	-0.1	1.0	U	None
UCT 14090	MMK 287	Mandibular Body	-10.9	12.9	Right Mand. M2	-2.0	-0.1	U	None
UCT 14091	MMK 189	Rib	-10.2	13.6	Right Mand. M3	-3.6	0.5	M	None
UCT 14092	MMK 238	Rib	-9.5	14.3	None			J	Tortoise shell fragments
UCT 14093	MMK 245	Rib	-9.8	13.7	Right Mand. M2	-6.3	1.2	J	O.E.S beads
UCT 14094	MMK 231	Rib	-9.7	11.6	Right Mand. M3	-4.0	4.0	M	None
UCT 14095	MMK 247 1	None			Left Mand. M3	-5.0	-0.1	J	Small bovid horn core
UCT 14096	MMK 247 2	None			Left Max. M2	-5.6	2.2	J	Small bovid horn core
UCT 14097	MMK 246	Rib	-8.2	13.9	None			J	O.E.S beads
UCT 14098	MMK 212	Mandibular Body	-12.8	14.0	Left Mand. M2	-5.3	0.3	U	None

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave Goods
UCT 14099	MMK 213	Rib	-10.5	15.0	Left Max. M3	-3.2	-0.9	F	Cu staining on right mastoid, zygomatic arch, right mandibular ramus & on right distal radius & ulna
UCT 14100	MMK 272	None			Left Mand. M3	-2.9	-0.2	U	String of O.E.S beads
UCT 14101	MMK 235	Rib	-8.9	11.1	Right Mand. M3	-1.7	-2.4	F	O.E.S beads, bored stone, complete undecorated & unburnished light brown miniature clay pot
UCT 14102	MMK 236	Rib	-10.1	11.4	Right Mand. M3	-3.8	0.8	F	bored stone, cowrie shells, complete unburnished & undecorated miniature lugged clay pot
UCT 14103	MMK 237	Rib	-9.2	12.8	Left Mand. M3	-2.6	0.2	F	Grindstone; Ringed & snapped mammal long bone, polished on one end
UCT 14104	MMK 209	Rib	-7.6	10.0	Right Mand. M3	0.6	-1.3	J	None
UCT 14105	MMK 325	Rib	-11.0	10.5	None			U	5 O.E.S beads, ochre
UCT 14106	MMK 208	Rib	-10.5	12.8	Left Mand. M3	0.4	0.6	M	Grindstone, agate on surface
UCT 14107	MMK 324	None			Right Mand. M2	-5.9	-1.1	U	No data

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave Goods
UCT 14108	MMK 322	Rib	-10.7	10.8	None			F	No data
UCT 14109	MMK 244	Rib	-9.9	14.4	Left Mand. M3	-4.6	1.6	U	Pot, grooved stone, sheep bone pendant (like MMK 249)
UCT 14110	MMK 335	Rib	-11.9	14.7	Right Mand. M3	-3.5	0.3	F	Cu staining on right mastoid region of cranium
UCT 14111	MMK 173	Rib	-10.3	14.7	Left Mand. M3	-4.5	0.2	M	No data
UCT 14112	MMK 286	None			Left Mand. M3	-3.4	0.5	U	No data
UCT 14113	MMK 316	Rib	-10.5	12.7	Left Mand. M3	-3.0	-1.1	J	O.E.S fragments, Cu staining on right mastoid region & zygomatic arch
UCT 14114	MMK 317	Rib	-10.1	13.2	Right Mand. M2 & M3	-7.2	-0.8	F	Cowrie shell, Cu button but no Cu staining on bones
UCT 14115	MMK 321	Rib	-11.8	14.7	Right Mand. M3	-7.8	0.7	M	Ochre on proximal half of left humerus, proximal end of left ulna, left tibia & fibula, and proximal end of right tibia & femur;ochred string of O.E.S beads; bored stone; perforated shell; specularite on top of skull
UCT 14116	MMK 296	None			Left Mand. M3	-4.8	1.6	M	Grindstone, ochre on individual, animal bones

UCT Archaeo-metry Laboratory No.	Access-ion No.	Bone Sampled	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$	Tooth Sampled	$\delta^{13}C_{ena}$	$\delta^{18}O_{ena}$	Sex	Grave Goods
UCT 14117	MMK 332	Rib	-9.7	14.4	Right Mand. M3	-4.0	5.4	U	No data
UCT 14118	MMK 334	Rib	-9.3	11.4	M3	-4.5	1.7	J	None
UCT 14119	MMK 143	Rib	-12.5	12.8	Left Mand. M3	-8.6	0.8	M	No data
UCT 14120	MMK 311	Femoral Shaft	-11.3	12.5	None			U	None
UCT 14121	MMK 281	Rib	-15.2	15.7	None			F	No data
UCT 14283	MMK 247	Rib	-8.4	12.5	None			U	Small bovid horn core
UCT 14381	A 330	Rib	-11.4	12.5	Right Max. M2	-3.1	0.2	M	Cut & polished mammalian long bone
UCT 14382	A 331	Rib	-10.0	12.7	Left Mand. M2	-3.7	-1.3	M	Bored stone, cowrie shell, O.E.S beads
UCT 14383	A 332	Rib	-12.6	14.5	Left Mand. M3	-2.6	-1.0	M	O.E.S beads
UCT 14384	A 333	Rib	-10.5	14.3	Left Max. M3	-2.7	-1.4	M	None
UCT 14385	A 334	Rib	-10.4	12.9	Left Mand. M3	-2.8	0.2	M	Cut & polished mammalian long bone
UCT 14386	A 326	Rib	-11.7	14.3	None			F	No data
UCT 14387	A 327	Rib	-9.5	11.2	Left Mand. M2	-0.9	-0.7	M	No data
UCT 14388	A 240	Rib	-9.9	13.4	Right Mand. M2	-4.2	1.0	J	No data
UCT 14389	A 123	Rib	-8.5	14.1	None			M	No data
UCT 14390	A 269	Rib	-9.6	13.0	Right Mand. M3	-3.2	2.8	M	Cu bracelet, Cu staining on left distal radius & ulna
UCT 14391	A 914	Rib	-12.8	12.8	None			U	No data
UCT 14392	A 2799	Rib	-8.8	10.9	Left Mand. M3	-2.5	-0.7	U	No data
UCT 14393	A 268	Rib	-9.1	13.2	Left Mand. M2	-3.1	1.7	M	O.E.S beads

Table 5.2: Collagen yields, weight %C and %N and C:N values for bone collagen samples.

UCT Archaeo-metry Laboratory No.	Accession No.	Collagen Yield (%)	Wt %C	Wt %N	Atomic C:N
UCT 14056	MMK 227	16	43.0	15,4	3,2
UCT 14058	MMK 252	14	46,8	16,7	3,3
UCT 14059	MMK 248	18	40,9	14,1	3,4
UCT 14060	MMK 330	24	43,1	15,7	3,2
UCT 14061	MMK 329	26	46,8	17.0	3,2
UCT 14062	MMK 249	14	43,1	15,7	3,2
UCT 14063	MMK 228	26	40,5	14,8	3,2
UCT 14064	MMK 195	18	40,4	14,7	3,2
UCT 14065	MMK 217	21	41,1	14,9	3,2
UCT 14066	MMK 218	27	42,6	15,4	3,2
UCT 14067	MMK 219	17	42,4	15,1	3,3
UCT 14068	MMK 223	9	41,9	15,0	3,3
UCT 14069	MMK 224B	4	42,5	14,2	3,5
UCT 14070	MMK 230	16	41,7	14,8	3,3
UCT 14071	MMK 230A	23	42,3	15,2	3,2
UCT 14072	MMK 229	23	42,9	15,5	3,2
UCT 14073	MMK 220	18	41,9	15,0	3,3
UCT 14074	MMK 203	4	42,5	14,9	3,3
UCT 14075	MMK 221	9	41,6	12,2	4.0
UCT 14076	MMK 222	10	43,3	14,1	3,6
UCT 14077	MMK 204	16	43,3	15,5	3,3
UCT 14078	MMK 190	20	42,5	15,4	3,2
UCT 14083	MMK 202	16	40,3	14,5	3,2
UCT 14084	MMK 206	18	41,8	15,3	3,2
UCT 14085	MMK 214	24	44,0	15,7	3,3
UCT 14087	MMK 239	17	37,7	13,5	3,2
UCT 14088	MMK 250	23	43,5	15,8	3,2
UCT 14089	MMK 255	11	43,2	13,7	3,7
UCT 14090	MMK 287	23	29,6	10,6	3,2
UCT 14091	MMK 189	20	41,3	14,8	3,3
UCT 14092	MMK 238	22	42,8	15,7	3,2
UCT 14093	MMK 245	19	40,5	14,6	3,2
UCT 14094	MMK 231	22	42,9	15,7	3,2
UCT 14097	MMK 246	22	42,5	15,1	3,3

UCT Archaeo-metry Laboratory No.	Accession No.	Collagen Yield (%)	Wt %C	Wt %N	Atomic C:N
UCT 14098	MMK 212	22	43,3	15,7	3,2
UCT 14099	MMK 213	28	43,9	16,0	3,2
UCT 14101	MMK 235	19	42,7	15,5	3,2
UCT 14102	MMK 236	16	31,3	11,4	3,2
UCT 14103	MMK 237	17	43,1	15,4	3,3
UCT 14104	MMK 209	28	43,9	16,0	3,2
UCT 14105	MMK 325	1	40,3	14,1	3,3
UCT 14106	MMK 208	17	42,9	15,4	3,3
UCT 14108	MMK 322	23	41,3	14,9	3,2
UCT 14109	MMK 244	23	42,6	15,4	3,2
UCT 14110	MMK 335	26	45,7	16,8	3,2
UCT 14111	MMK 173	24	41,5	15,0	3,2
UCT 14113	MMK 316	26	43,3	15,8	3,2
UCT 14114	MMK 317	25	42,1	15,2	3,2
UCT 14115	MMK 321	17	42,6	15,4	3,2
UCT 14117	MMK 332	13	24,1	8,6	3,3
UCT 14118	MMK 334	2	38,6	13,6	3,3
UCT 14119	MMK 143	14	43,4	15,6	3,3
UCT 14120	MMK 311	16	42	14,9	3,3
UCT 14121	MMK 281	20	45,4	16,6	3,2
UCT 14283	MMK 247	20	43,0	15,9	3,2
UCT 14381	A 330	15	42,1	15,1	3,2
UCT 14382	A 331	16	43,9	15,5	3,3
UCT 14383	A 332	10	41,2	14,7	3,3
UCT 14384	A 333	21	43,9	15,9	3,2
UCT 14385	A 334	23	41,0	14,8	3,2
UCT 14386	A 326	22	43,3	15,7	3,2
UCT 14387	A 327	26	42,5	15,4	3,2
UCT 14388	A 240	14	37,1	13,4	3,2
UCT 14389	A 123	16	42,3	15,3	3,2
UCT 14390	A 269	25	43,4	15,8	3,2
UCT 14391	A 914	12	42,1	15,0	3,3
UCT 14392	A 2799	14	40,5	14,5	3,2
UCT 14393	A 268	11	41,9	14,9	3,3

Comparison of Isotope Values in Adults and Juveniles

Fig. 5.5 shows a plot of $\delta^{15}N_{collagen}$ vs $\delta^{13}C_{collagen}$ for bone collagen from adults compared with juveniles. The distribution of $\delta^{15}N_{collagen}$ values in the two groups is not significantly different (Mann-Whitney Z-value= 0.20; p= 0.84, and T-test for two independent samples, t= 0.05, p= 0.05, df= 51), nor is there any difference in the distribution of $\delta^{13}C_{collagen}$ (Mann-Whitney Z-value= 1.18; p= 0.24, and T-test for two independent samples, t= 1.39, p= 0.05, df= 51). Fig. 5.6 shows the distribution of $\delta^{13}C_{enamel}$ values for both adults and juveniles. There is no statistical significance between $\delta^{13}C_{enamel}$ in the two groups (Mann-Whitney Z-value= -0.40; p= 0.68, and T-test for two independent samples, t= 0.03, p= 0.05, df= 32).

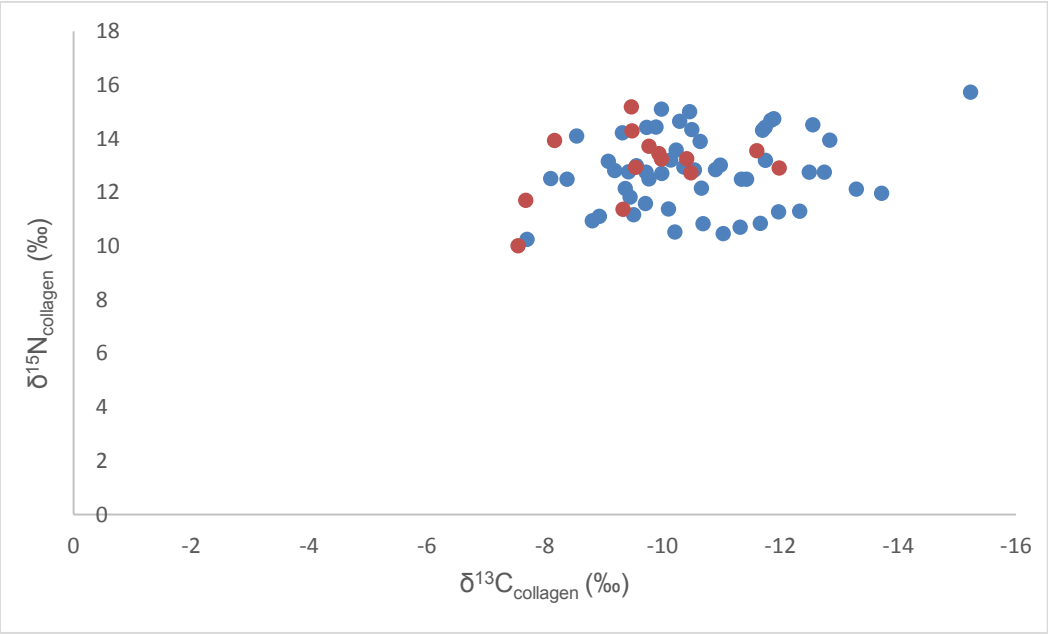

Figure 5.5: Distribution of $\delta^{13}C$ and $\delta^{15}N$ values for adults (blue) in relation to juveniles (red).

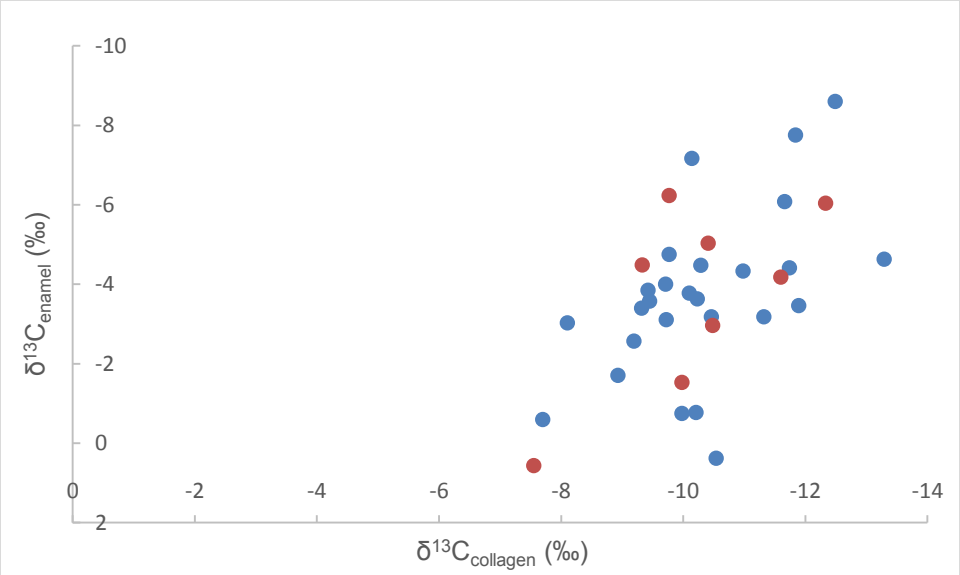

Figure 5.6: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$ values for adults (blue) versus juveniles (red).

Comparison of Isotope Values in Males and Females

Isotope studies have afforded researchers the opportunity to investigate questions about dietary and subsistence patterns in past communities in more detail than was previously possible, e.g. comparing different sexes. Fig. 5.7 illustrates the distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for males and females in order to show the differences (or lack thereof) in the diets of men and women. The mean $\delta^{13}C_{collagen}$ for females is -10.7±1.6‰ while that of males is -10.4±1.5‰ (Mann-Whitney Z-value= -0.08; p= 0.94, and T-test for two independent samples, t= 0.55, p= 0.05, df= 37). The exclusion of the outlier, MMK 281, shifts the mean for females to -10.4±1.0‰. There is no statistically significant difference between males and females. The mean $\delta^{15}N_{collagen}$ for females is 12.6±1.7‰ and the value for males is 13.1±1.3‰ (Mann-Whitney Z-value of -1.27; p= 0.23, and T-test for two independent samples, t= 1.13, p= 0.05, df= 37). Mean $\delta^{13}C_{enamel}$ for males is -3.7±2.0‰ and for females it is -3.7±1.7‰ (Mann-Whitney Z-value= -0.07; p= 0.94, and T-test for two independent samples, t= 0.29, p= 0.05, df= 33) (see Fig. 5.8). In this population, there are no dietary differences between men and women that can be distinguished using carbon and nitrogen isotopes.

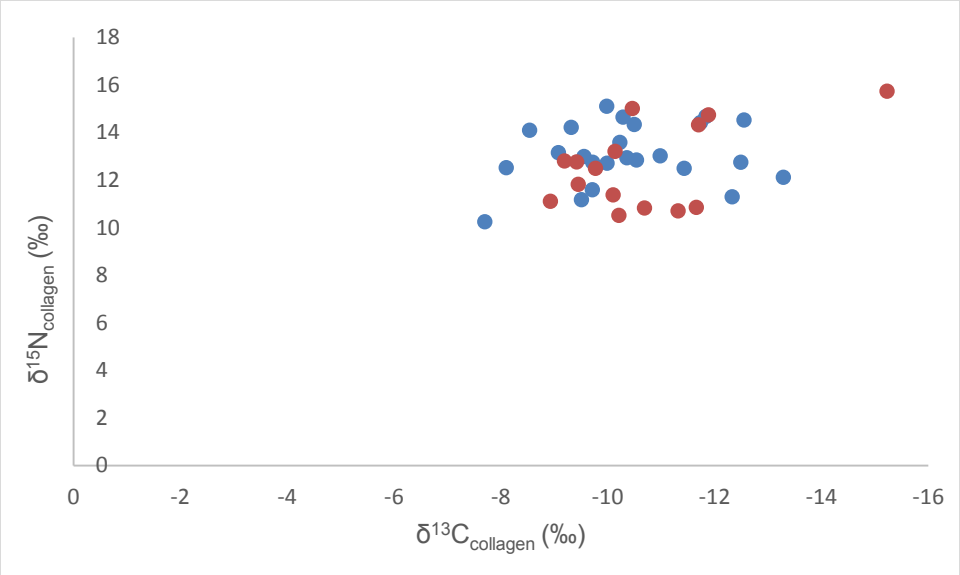

Figure 5.7: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for males (blue) in relation to females (red).

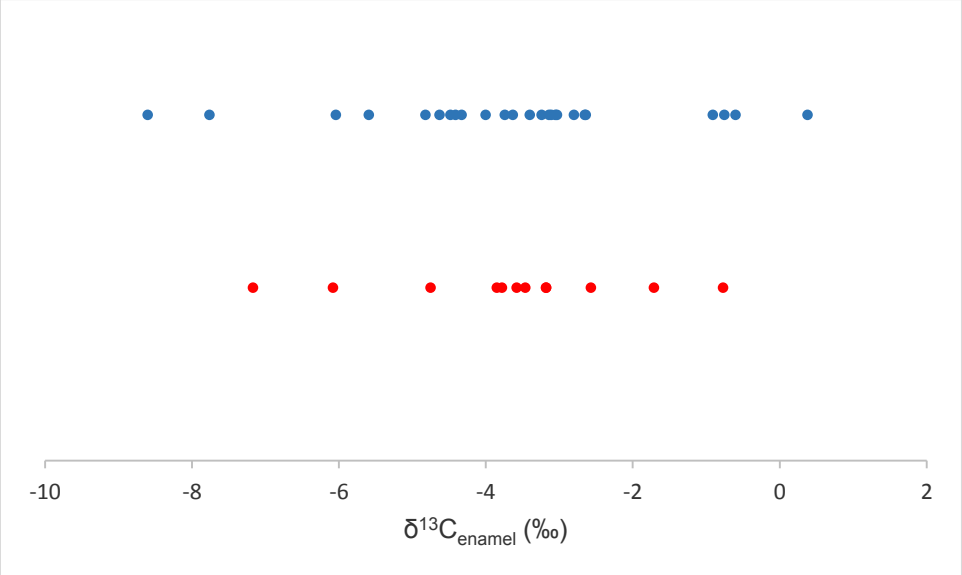

Figure 5.8: Distribution of $\delta^{13}C_{enamel}$ for males (blue) and females (red).

Copper Discoloration of Bone Elements in Human Burials as an Indication of the use of Copper Ornaments

The observation of green stains on some human skeletal remains from the Northern Cape Province and the Western Orange Free State was first noted by Morris (1981), and attributed to copper staining, although copper artefacts had not necessarily been recovered from all of these graves. The most common areas of discolouration were on the mastoid process of the cranium,

on the lateral surface of the vault, on the bones of the forearm, and on the condyles of the mandible (Morris 1981). These locations are associated with the types of copper ornament that might have been originally buried with an individual. For instance, staining of the forearm is linked to bracelets, while ear-rings would be responsible for staining on the mandibular condyle and/or the mastoid area of the cranium. In this study five individuals (MMK 249, MMK 228, MMK 213, MMK 335 and MMK 316) were noted to have copper discolouration but copper ornaments were not recovered. In other cases, copper ornaments were found: MMK 287 was found with a copper bracelet and discolouration on the left radius and ulna, while the MMK 317 burial presented a copper button but no staining (Table 5.1). The presence of copper ornaments, copper staining, cowrie shells and glass beads thus affords the opportunity to look into questions of long-distance trade and interaction of Riet River populations, including those with groups practising different subsistence strategies, such as the Sotho-Tswana agriculturalists.

Individuals Buried with, and those Buried without Grave Goods

Fig. 5.9 shows the distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for individuals with grave goods that would have been obtained locally or through long distance trade. The grave goods include glass beads, cowrie shells, specularite and copper artefacts or signs of discoloration of bone from copper staining. The $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values of these individuals are compared to those of individuals who were found without grave goods, described as “none” or “no data” by the collector. The distribution between the 2 groups shows no significant difference (Mann-Whitney Z-value= -0.44; p= 0.66, and T-test for two independent samples, t= -0.19 at p= 0.05 with a df =26 for $\delta^{13}C_{collagen}$; T-test for two independent samples; Mann-Whitney Z-value= -0.06; p= 0.95, and t= 0.60 at p= 0.05 with a df= 26 for $\delta^{15}N_{collagen}$, and Mann-Whitney Z-value= -1.34; p= 0.18; T-test for two independent samples, t= 0.97 at p= 0.05 with a df= 21 for $\delta^{13}C_{enamel}$). (MMK 281 has been excluded from this statistical comparison because, as an outlier, she is likely to skew the result.)

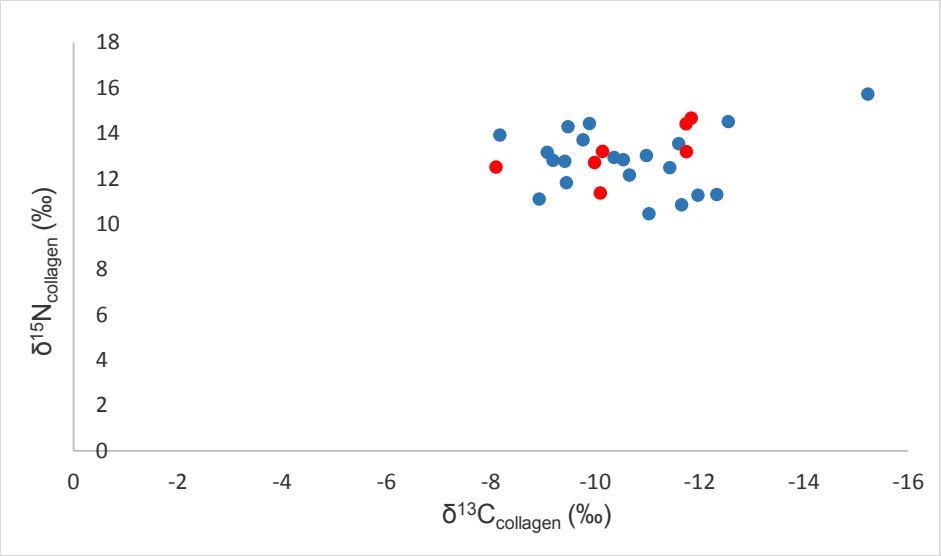

Figure 5.9: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for individuals buried with (red) and those buried without grave goods (blue).

Individuals Buried with Grave Goods of Interior Origin and those Buried with Grave Goods that Indicate Long-Distance Trade

Fig. 5.10 shows the distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for individuals who were found with grave goods of interior origin and those buried with goods that indicate long-distance trade. Artefacts of interior origin include specularite and copper artefacts and/or visibility of copper staining of the bone, while the long distance artefacts include cowrie shells and glass beads (Table 5.4).People consumed isotopically similar diets, irrespective of the nature of the grave goods with which they were recovered (Mann-Whitney Z-value of -0.71 at p= 0.48, and T-test for two independent samples, t= 0.43, p= 0.05, df= 12 for $\delta^{13}C_{collagen}$; Mann-Whitney Z-value= -2.07, p= 0.04, and T-test for two independent samples, t= 0.55, p= 0.05, df= 12 for $\delta^{15}N_{collagen}$. The Mann-Whitney Z-value is -1.29 at p= 0.20, and T-test for independent samples, t= 2.32, p = 0.05, df= 12 for $\delta^{13}C_{enamel}$, indicating no significant differences between the two groups).

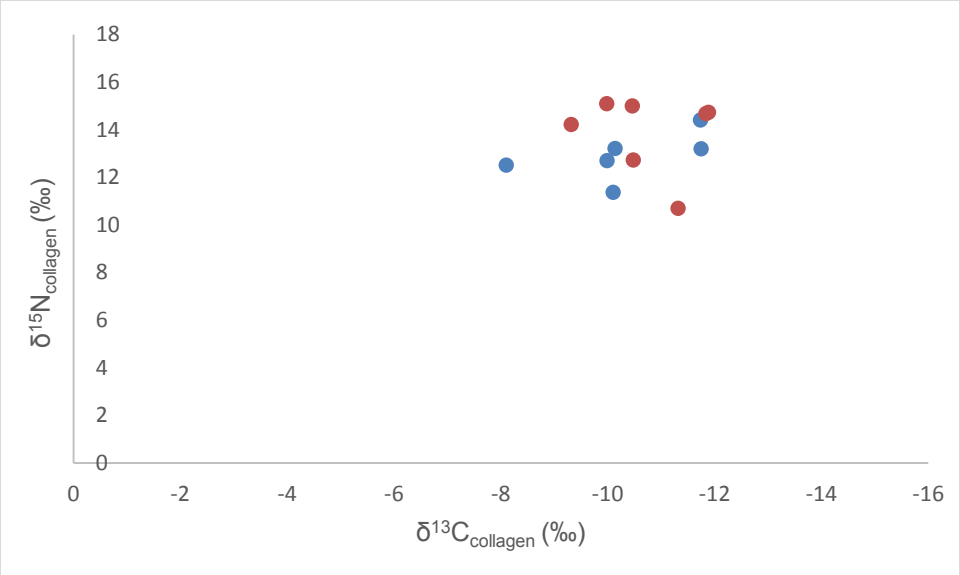

Figure 5.10: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for individuals buried with grave goods obtained in the interior (red) and those buried with graves goods obtained through long-distance trade (blue).

Comparison of Isotope Values Based on Nature of Grave Goods in Males and Females

Males

Another social aspect that is explored by the author is whether there is a significant difference in diets of males and females based on the nature of the grave goods with which they were recovered. Fig. 5.11 shows the distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for males relative to the grave good type. The grave goods considered are cowrie shells, glass beads, specularite and copper artefacts or the presence of copper staining on any given location of a skeleton. The author groups these grave goods into two categories; specularite and copper artefacts are grouped as locally obtained and cowrie shells and glass beads are considered long-distance trade objects. The numbers are too small for statistical treatment, but there seem to be no obvious differences between the two groups (Fig. 5.11; Fig. 5.12).

The $\delta^{15}N_{collagen}$ distribution shows a different pattern. From Fig. 5.11, it appears that the individuals with copper staining and/or copper artefacts have more enriched $\delta^{15}N_{collagen}$ values. The sample subset is small, with just six individuals buried with objects that indicate trading. Again, the numbers are too small to perform a statistical test. However, there appears to be a difference between individuals buried with specularite and copper artefacts and/or copper staining, and those buried with cowrie shells and/or glass beads.

Females

The distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for female skeletons who were buried with specularite and copper artefacts and/or copper staining (local grave goods) relative to those buried with cowrie shells and/or glass beads (long-distance grave goods) is represented in Fig. 5.13. Overall, all individuals appear to be loosely clustered. However, more specifically, the two individuals with exotic burial goods have similar $\delta^{15}N_{collagen}$ values (11.4‰ for UCT 14102 and 13.2‰ for 14114) and identical $\delta^{13}C_{collagen}$ values (-10.1‰). This is different from the group with local grave goods, whose $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values are more spread. Fig. 5.14 has produced a loose cluster in all but individual (UCT 14114) whose depleted $\delta^{13}C_{enamel}$ value causes it to be an outlier. Like the male sample, the number is too small to perform a statistical test.

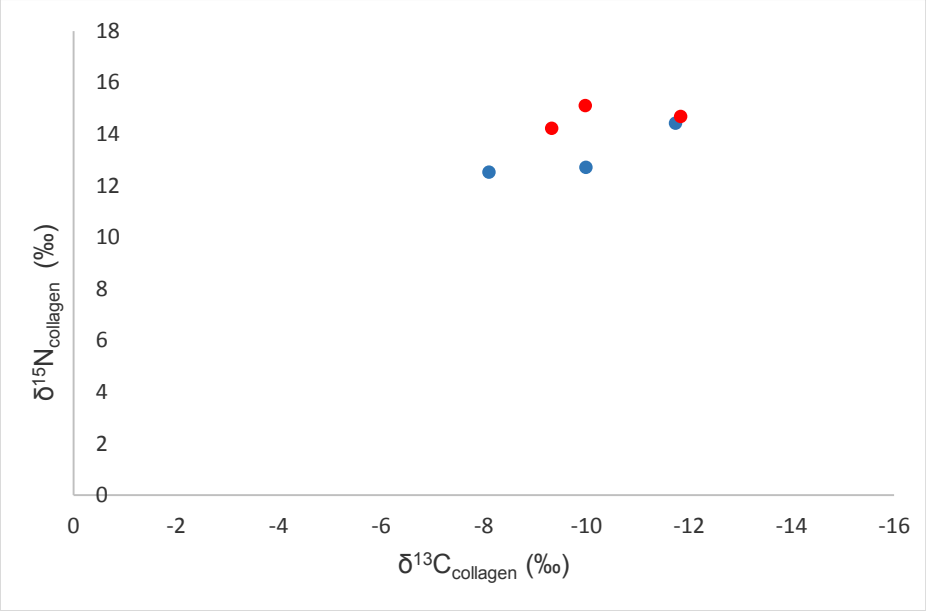

Figure 5.11: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ of males buried with locally obtained (red) and long-distance grave goods (blue).

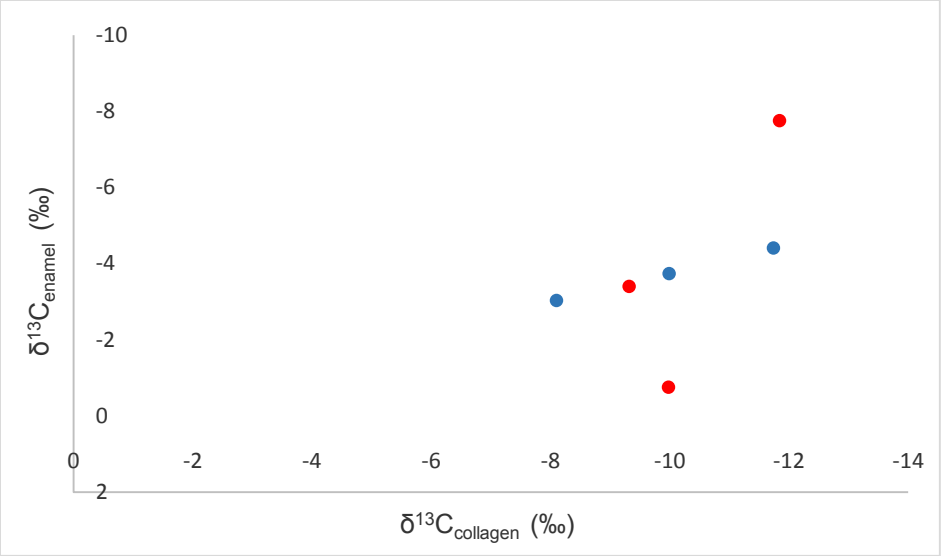

Figure 5.12: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$ of males buried with locally obtained (red) and long-distance grave goods (blue).

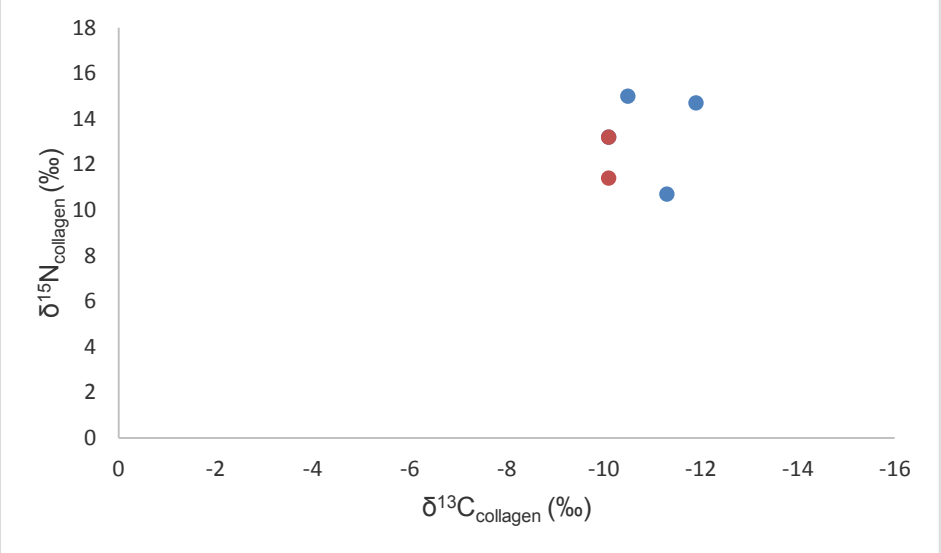

Figure 5.13: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ of females buried with locally obtained (blue) and long distance grave goods (red).

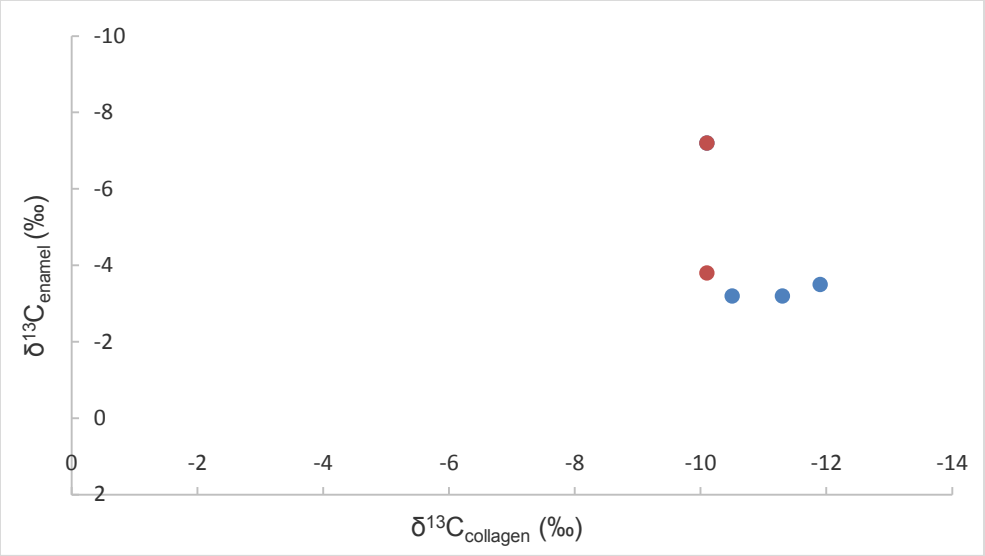

Figure 5.14: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$ of females buried with locally obtained (blue) and long distance grave goods (red).

Juveniles Buried with Grave Goods versus Juveniles Buried without Grave Goods

Fig. 5.15 shows the distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for juveniles who were recovered with and without burial goods. The $\delta^{15}N_{collagen}$ values for juveniles with burial goods are more enriched relative to those without burial goods. A Mann-Whitney U Test shows no statistically significant difference between the two categories (Mann-Whitney Z-value of -0.60, p= 0.55; T-test for two independent samples, t=0.49, p=0.05 and df= 12 for $\delta^{13}C_{collagen}$, and Mann-Whitney Z-value= 1.67; p= 0.10, with T-test for two independent samples, t= 1.75, p= 0.05 and df= 12 for $\delta^{15}N_{collagen}$).The nature of archaeological studies is the dearth of data from which to work, thus making enquires a challenge. The total juvenile data set comprises only 16 individuals (some of which had no bone from which to sample). Although this result is interesting, it will need to be confirmed through analysis of a larger number of individuals before we can confidently come to any conclusions.

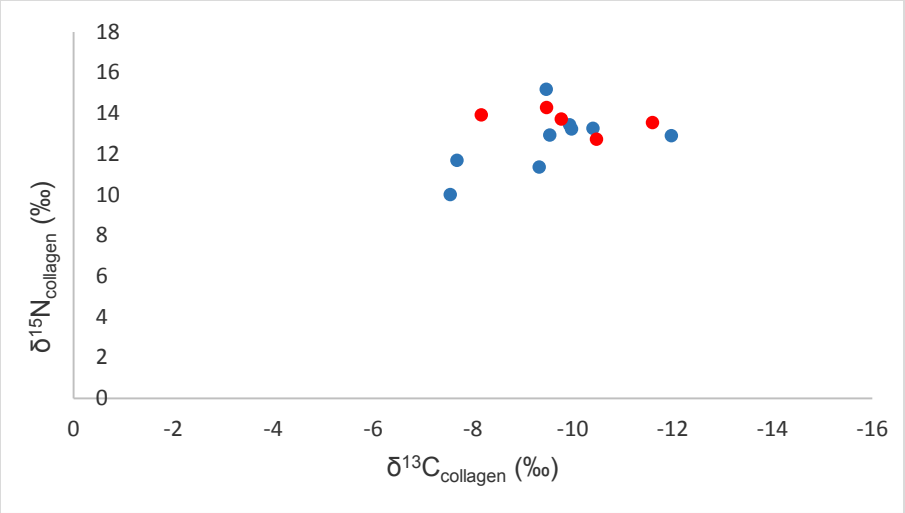

Figure 5.15: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for juveniles buried with (red) and without grave goods (blue).

Comparison of Isotope Values Based on Locality of Burial

Given the poor archaeological controls on the excavation of these individuals, this series of skeletons may include both people from the archaeological, late precolonial Riet River community, and others such as farm workers on early colonial-era farms. If this is the case, the degree of variation in the isotopes might be a result of different populations with different dietary habits. Graves that were found near or in a stone settlement or kraal, or at least within half a kilometre from the Riet River are considered to be clearly associated with Type-R settlements, and are therefore considered as part of the Riet River population. The rest of the graves are marked as not clearly associated with Type-R settlements, and the possibility exists that they do not belong to the precolonial Riet River population. Fig. 5.16 shows a distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for skeletons that are clearly, and those that are not clearly associated with Type-R settlements. Fig. 5.17 depicts the same relationship, only with $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$ values. There is no difference in the distribution of isotope values of the skeletons clearly associated with Type-R settlements and those that are not (Mann-Whitney Z-value= -1.58; p= 0.11, and T-test for two independent samples, t= 0.07, p= 0.05, df= 66 for $\delta^{13}C_{collagen}$; Mann-Whitney Z-value= -0.54; p= 0.59, and T-test for two independent samples, t= 0.87, p= 0.05, df= 66 for $\delta^{13}C_{enamel}$; Mann-Whitney Z-value= -0.91, p= 0.36, and T-test for two independent samples, t= 1.04, p= 0.05, df= 51 for $\delta^{15}N_{collagen}$). Therefore, the author proceeds on the basis that all of these individuals are indeed members of the archaeological Riet River community.

$\delta^{13}C_{enamel}$ Values of a Cow Molar

Fig. 5.18 and Table 5.3 show $\delta^{13}C_{enamel}$ and $\delta^{18}O_{enamel}$ values for an archaeological cow molar recovered from the surface of site OFD1 during a visit in May 2013. Four horizontal bands of enamel were drilled across the crown of the tooth to sample different periods of growth. The first sample listed in Table 5.3 (UCT 15397) is from near the occlusal surface of the tooth, reflecting an earlier period of diet, while the fourth (UCT 15400) comes from near the cementum-enamel junction and reflects a more recent period of growth. The $\delta^{13}C_{enamel}$ measurements range from 0.3‰ to 1.5‰, while the mean is 1.1‰ ±0.6‰ (n=4).The positive $\delta^{13}C_{enamel}$ values, as shown in Table 5.3, indicate consistent grazing on C_4 grasses across seasons. If this cow is typical, then cattle-based foods (milk and meat) would have contributed strongly C_4-based isotopic values to people's diets.

The $\delta^{18}O_{enamel}$ measurements range from 1.6 to 5.6‰, with a mean of 3.6±1.7‰ (n=4). This is more positive than the range for humans, -2.4 to 5.6‰, with a mean of 0.4±1.4‰. It is likely that both humans and animals would have consumed water from the same source. Thus, the more depleted $\delta^{18}O_{enamel}$ mean for humans might be a result of a number of reasons including physiological factors. The area under study is an arid to semi-arid environment which would have made the adaptation to heat stress important for survival. Heat stress influences oxygen isotope composition. Cows cool themselves by both sweating and panting, and liquid water lost through sweat is isotopically enriched compared to water vapour in panting (Wong *et al.* 1988; Sponheimer & Lee-Thorp 1999). Thus, animals that pant will retain more ^{18}O in their body tissues. Diet also has an effect on $\delta^{18}O_{enamel}$ values as different food such as stems, roots, leaves and animal flesh have characteristic $\delta^{18}O_{enamel}$ values.

Table 5.3: $\delta^{13}C_{enamel}$ and $\delta^{18}O_{enamel}$ values for a cow molar.

UCT Archaeo-metry Laboratory No.	$\delta^{13}C_{enamel}$	$\delta^{18}O_{enamel}$
UCT 15397	0.3	1.6
UCT 15398	1.4	3.0
UCT 15399	1.3	4.3
UCT 15400	1.5	5.6

Table 5.4: Individuals found with local grave goods (LGG) and those found with long-distance grave goods (LDGG).

Sample	Grave Goods Type
UCT 14056	LGG
UCT 14061	LGG
UCT 14062	LGG
UCT 14099	LGG
UCT 14110	LGG
UCT 14113	LGG
UCT 14115	LGG
UCT 14058	LDGG
UCT 14063	LDGG
UCT 14087	LDGG
UCT 14102	LDGG
UCT 14114	LDGG
UCT 14382	LDGG

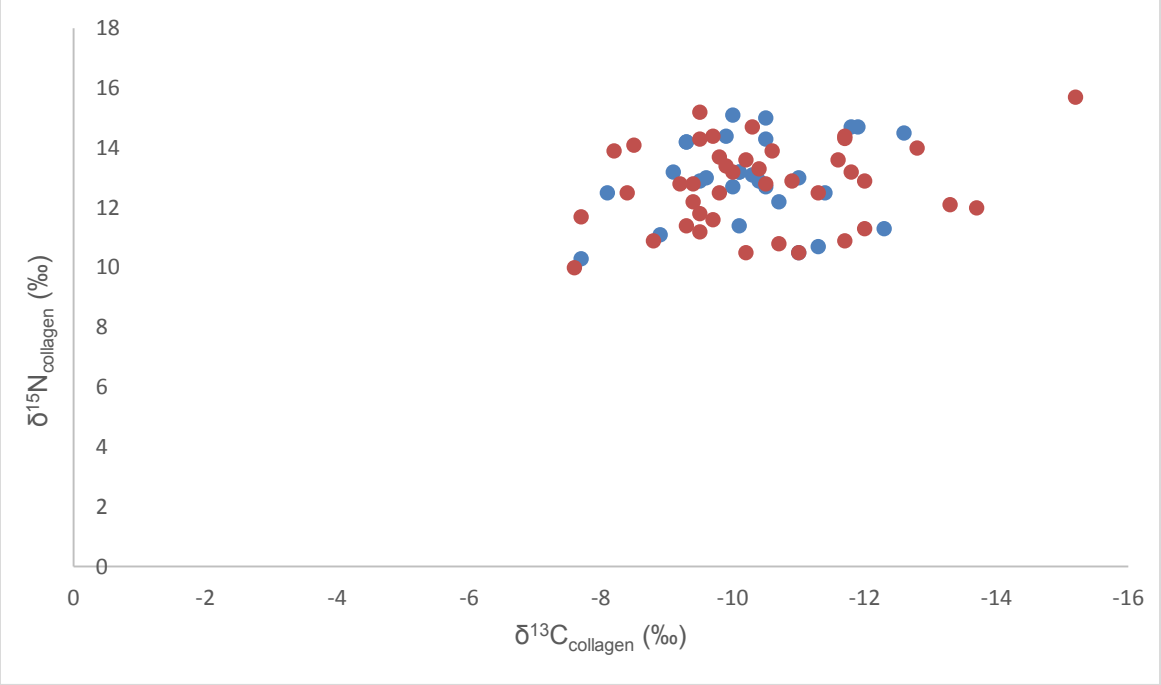

Figure 5.16: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values for skeletons that are clearly (blue), and those that are not clearly associated with Type-R settlements (red).

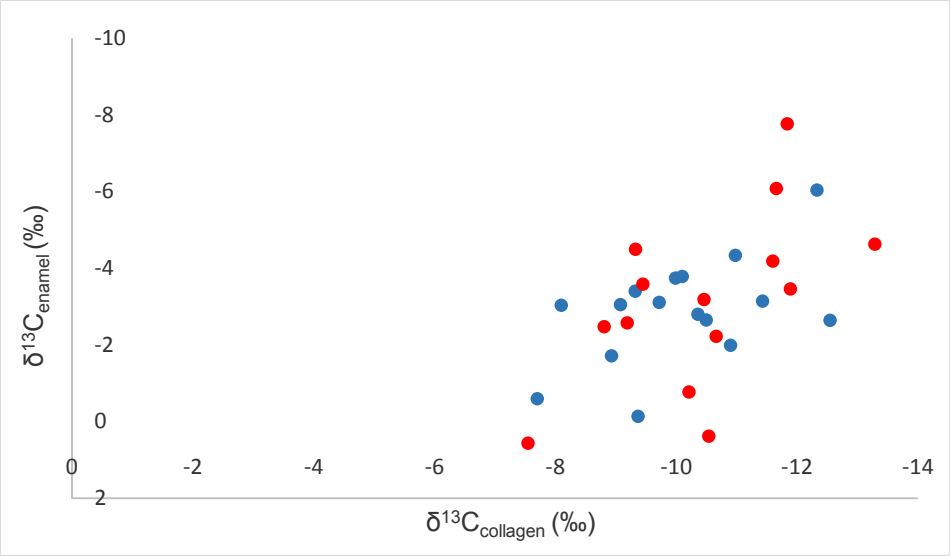

Figure 5.17: Distribution of $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$ values for skeletons that are clearly (blue), and those that are not clearly associated with Type-R settlements (red).

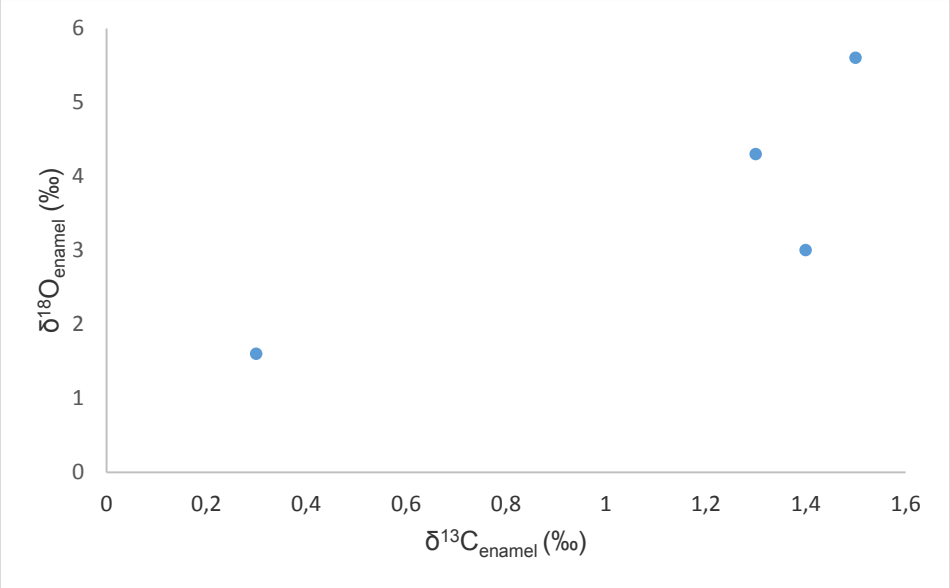

Figure 5.18: Distribution of $\delta^{13}C_{enamel}$ and $\delta^{18}O_{enamel}$ values for an archaeological cow molar from OFD1.

Conclusion

This chapter has reported the $\delta^{13}C_{collagen}$, $\delta^{15}N_{collagen}$, $\delta^{13}C_{enamel}$ and $\delta^{18}O_{enamel}$ results for 80 archaeological human skeletons and one cow molar from the Riet River. In the next chapter, these results are discussed within the context of relevant ethnographic, historic and archaeological accounts of the area, and previous studies that have used stable isotopes to reconstruct diet in archaeological communities from this region.

Chapter Six:

Discussion and Conclusion

This chapter is concerned with further exploring and interpreting the results reported in the previous chapter in relation to questions about the identity and economy of the Riet River communities, as outlined earlier in the thesis. These questions include: What was the extent of outsider incorporation into the Riet River communities? What was the relative importance of herding versus hunting and gathering? Archaeological evidence and historical accounts indicate that the Riet River people traded in non-food items such as copper artefacts and specularite. Therefore, with the assistance of isotope data, the question of whether these communities were involved in the trading of food items such as meat and grain, is addressed. The relationship between the $\delta^{13}C$ values of bone collagen and tooth enamel of the same individual is discussed in relation to previously published work on this topic.

$\delta^{13}C$ and $\delta^{15}N$ Isotope Patterning: A Comparison with Previous Studies

The scatterplot of $\delta^{13}C$ against $\delta^{15}N$ of bone collagen (Fig. 5.3) is telling in as far as it shows a loose cluster of points with a range of approximately 7‰ in $\delta^{13}C$ and 6‰ in $\delta^{15}N$. The range of $\delta^{13}C$ values is very similar to that of the much smaller number of Riet River skeletons analysed by Lee-Thorp et al. (1993), but the range in $\delta^{15}N$ is wider. This indicates the exploitation of a wide range of food resources by this particular community. These would have included C_4 based foods such as animal products from wild and domesticated grazing animals, as well as C_3 foods such as berries, tubers and underground plant storage organs like corms, and animal products from browsing (C_3-eating) animals. Mixed feeders such as springbok, impala and sheep would also have contributed. As already mentioned in Chapter 2, sites such as Renosterkop 1 & 2, Waterval, Droegrond, OFD1 and Khartoum have produced archaeological evidence of diet in the form of faunal material. The Orange and Riet Rivers, with their abundance of riverine resources, probably played an important role in providing an additional food source for people. Archaeological evidence is scarce, with OFD1 being the only known site in the Riet River area that indicates riverine exploitation in the form of one fish bone. The dearth of physical evidence is, however, likely to be more an indication of preservation factors than it is evidence of absence. People are expected to have taken advantage of all available resources to ensure survival.

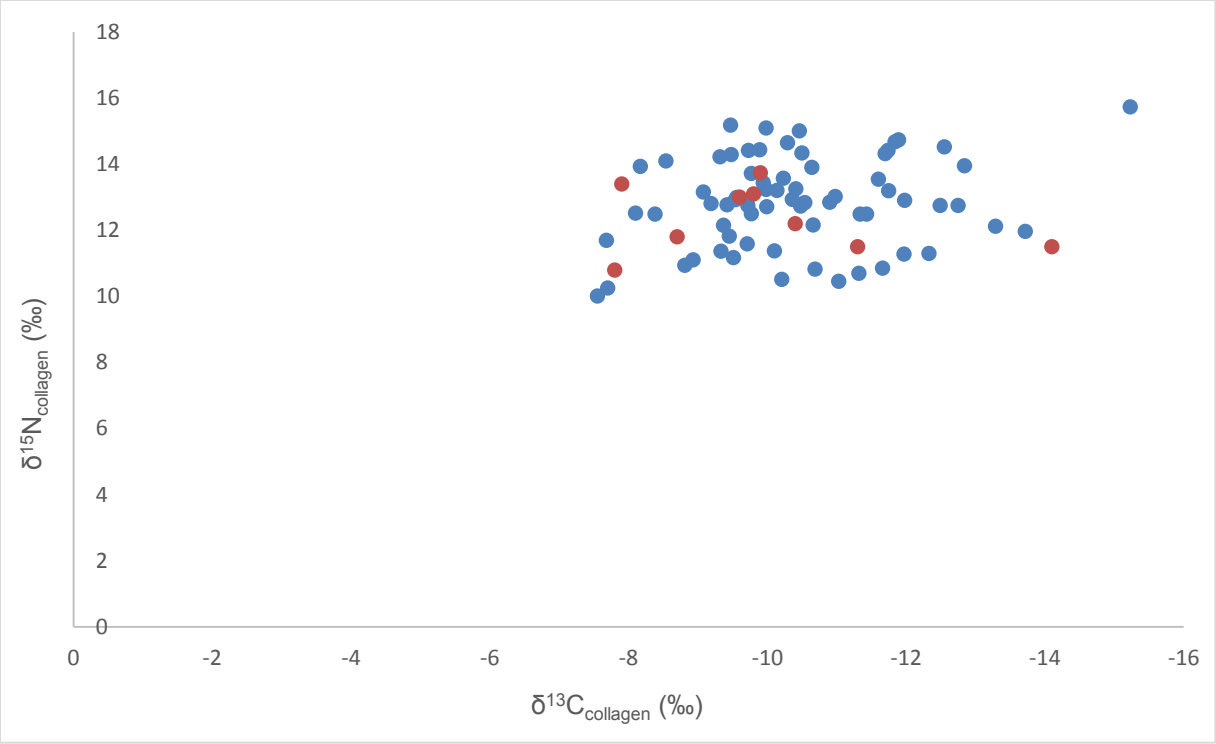

Figure 6.1: Scatter plot of $\delta^{13}C$ against $\delta^{15}N$ for all human skeletons in this study (blue) compared with nine of the Riet River skeletons curated in the National Museum, Bloemfontein, and reported in Lee-Thorp *et al.* (1993) (red).

A scatterplot of the same variables for individuals that are clearly associated with the Type- R settlements (Fig. 5.16) and those for whom the association is less clear indicates no difference in dietary exploitation patterns between the two groups (Mann-Whitney Z-value= 1.58; p= 0.11, and T-test for two independent samples, t= 0.07, p= 0.05 and df= 66 for collagen carbon; Mann-Whitney Z-value= -0.91, p= 0.36, and T-test for independent samples, t=0.87, p=0.05, df=66 for nitrogen). This excludes MMK 281 (UCT 14121), with a $\delta^{13}C$ value of -15.2‰, which lies at the most depleted end of the dietary spectrum. This implies that all individuals (apart from one or two outliers discussed in more detail below) most likely formed part of the same society and exploited the same food resources. In many cases, the individuals who are not clearly associated with Riet River settlements probably simply lack sufficient contextual archaeological evidence. In further investigation of this data set, the 'securely associated' and 'less securely associated' groups will be considered as one.

The individuals MMK 330 (with $\delta^{13}C$ of -7.7‰ and $\delta^{15}N$ of 10.3‰) and MMK 209 ($\delta^{13}C$ of -7.6‰ and $\delta^{15}N$ of 10.0‰), are positioned on the C_4 end of the dietary spectrum. These $\delta^{13}C$ values indicate the consumption of strongly C_4 diets including foods such as domesticated animals and possibly domesticated cereals. In contrast, the $\delta^{13}C$ and $\delta^{15}N$ values of Riet River skeletons at

the C_3 end of the distribution (notably MMK 281 with $\delta^{13}C$= -15.2‰ and $\delta^{15}N$= 15.7‰) reflect a typical hunter-gatherer diet of hunted game, wild plants such as underground storage organs, berries, and riverine resources. In their study of the diet and subsistence patterns of prehistoric farmers in South Africa using stable carbon and nitrogen isotopes, Lee-Thorp *et al.* (1993) included a number of Iron Age farming skeletons from the sites of Rustenburg, Paardekraal, Olifantspoort, Buispoort, Derdepoort, Irene Cave, Welgegund, Lindley, and Vrede (Fig. 1.1). These are the closest Iron Age farmers available for comparison with the Riet River. They would have consumed diets based on C_4 crops and domesticated stock. A plot of the $\delta^{13}C_{collagen}$ and $\delta^{15}N_{collagen}$ values (Fig. 6.1; Fig. 6.2) of these individuals in relation to the skeletons in this study indicates an overlap in distribution.

The Riet River individuals (MMK 209, MMK 228, MMK 230, MMK 235, MMK 330, MMK 247 and A 2799) with the strongest C_4 dietary signals overlap with the Iron Age group (Fig. 6.2) and may be important in elucidating the extent of outsider incorporation into Riet River society. These seven individual include males (MMK 228 and MMK 330), a female (MMK 235) and juveniles (MMK 209 and MMK 230). MMK 235 and MMK 228 have some unusual grave goods including a complete undecorated and unburnished light brown miniature clay pot as well as a bored stone from the former, and copper staining on the latter individual. It is suggested by the author that perhaps all these individuals were once part of an Iron Age community, and for unknown reasons, joined the Riet River population. An alternative explanation has to do with the possibility of food trade with Iron Age neighbouring groups. These few individuals might always have been part of the Riet River community, trading in cultigens with their farmer neighbours. That only a few individuals have $\delta^{13}C$ values as positive as this is an indication that trading in food such as cultigens does not appear to have played a significant role in the Riet River economy.

MMK 329 (UCT 14061), a male buried near to a stone-walled settlement at OFD1, was found with a copper plate pendant characteristic of those that are known to have been worn by Tswana males of high status (Burchell 1953). His $\delta^{13}C$ value of -9.3‰ and $\delta^{15}N$ of 14.2‰ does not stand out from the rest of the population. Contrary to other societies, including Iron Age groups in other parts of the world (Jay & Richards 2006; Kinaston *et al.* 2013; Le Bras-Goude *et al.* 2013), who may show dietary differences between social classes (sex, age or social status), this indicates dietary homogeneity within the Riet River community. MMK 277, a female recovered in Weltevrede and is dated to 890±50 years BP, shows with copper staining around the right mastoid area, caused by conical copper earrings (‘extinguishers’). She has a $\delta^{13}C$

value of -11.3‰, which clusters with the rest of the distribution, and a $\delta^{15}N$ of 10.7‰, one of the lowest in the population. Overall, it appears that both males and females of the Riet River communities wore ornaments made from sheet copper, as indicated by MMK 277.

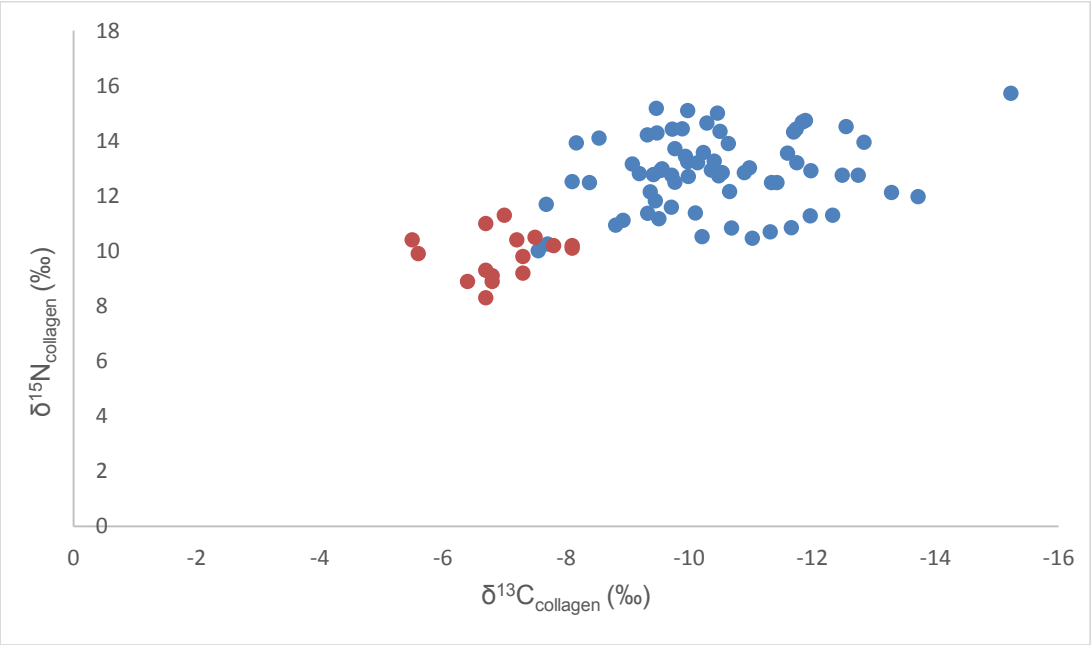

Figure 6.2: Scatter plot of $\delta^{13}C_{collagen}$ against $\delta^{15}N_{collagen}$ for the Riet River (blue) and Iron Age individuals (red) from Lee-Thorp *et al.* 1993. Iron Age skeletons from Bambandanyalo, Skutwater, Smitsdorp, Makapansgat, Bambo, Nysvlei, Settlers, and Kalkbank reported in Lee-Thorp *et al*. (1993) are not included here, since those sites are relatively distant from the Riet River and local vegetation types and environmental conditions are very different. Two supposedly Iron Age individuals (A 233 and A 1084) from Heilbron, also reported in Lee-Thorp *et al*. (1993), have also been excluded. A 233 is dated to 1000±60years BP (Pta-5218), pre-dating the settlement of this area by Iron Age farmers. A 1084 has not been dated, but is likely to be of similar age.

Relationship between $\delta^{13}C_{collagen}$ and $\delta^{13}C_{enamel}$

The scatter plot of $\delta^{13}C_{collagen}$ versus $\delta^{13}C_{enamel}$ for the individuals in this study (Fig. 5.4) shows a very poor correlation (R^2= 0.24). This is much lower than has been reported in previous studies, such as Loftus & Sealy's (2012) sample of South African coastal hunter-gatherers for whom the R^2 value was 0.70, and the historical North American human remains studied by France and Owsley, where the R^2 value was 0.88. To understand the probable causes for the discrepancy in correlation across the studies, it is necessary to understand the metabolic pathways from consumption of food to tissue synthesis. The diet of an average human contains three major macronutrients, namely, carbohydrates, lipids and proteins. Experimental studies have shown that carbohydrates and lipids are mainly utilized for energy metabolism, producing carbon

dioxide in the process (Ambrose & Norr 1993; Froehle & Schoeninger 2010; Howland *et al.* 2003; Kellner & Schoeninger 2007). The oxygenated carbon is transported to the lungs as blood bicarbonate, and expired as carbon dioxide (Krueger & Sullivan 1984). Thus, hydroxyapatite, which incorporates carbon atoms from blood bicarbonate, will display an isotopic composition derived from carbohydrates and lipids that have been used for energy metabolism (Krueger & Sullivan 1984), with some contribution from protein (unless the diet is very protein-poor). The $\delta^{13}C$ values of tooth enamel from the Riet River, therefore, are likely to reflect all components of the diet.

Bone collagen carbon, on the other hand, is carried within protein molecules. If a diet contains enough protein, the majority of the amino acids required for bone collagen growth and tissue replacement will be sourced from that protein. Overall, therefore, the $\delta^{13}C$ value of collagen reflects that of dietary protein (Ambrose & Norr 1993, but see also Howland *et al*. 2003). Therefore, if individuals consumed isotopically varied diets, with differences in the $\delta^{13}C$ values of carbohydrates, fats and proteins, metabolic factors of this kind could lead to discrepancies in the relationship of the $\delta^{13}C$ of bone collagen and tooth enamel.

In the case of the Riet River, we know that people were eating isotopically varied foods: C_3 and C_4-based foods, including plant, animal and very likely aquatic resources. Given our present state of knowledge, this seems to be the most likely reason why the Riet River population shows such a poor correlation between $\delta^{13}C$ of collagen and enamel. Further work, especially analysis of archaeological food remains and modern examples of foods eaten by Riet River people, may throw more light on this question.

Integrating the Archaeological and Isotopic Data of the Riet River Area: Lifestyle Implications

The isotopic patterns that have been discussed have the potential to inform the archaeological questions that this study addresses. That there are (sometimes very large) stock pens forming part of the Riet River settlements is significant. It attests to the importance that stock-keeping seems to have had in the lives of Riet River societies. However, the $\delta^{13}C$ and $\delta^{15}N$ distribution of the population shows that C_3-based foods were important in the diets of Riet River people - probably more important than one would expect if livestock was the major food source. It is highly likely that individuals took advantage of the presence of livestock by using their product (milk) and perhaps also produced a by-product from the milk, such as butter. Domestic stock was economically and perhaps socially significant for Riet River populations. As among other

herding communities in southern Africa, slaughtering is likely to have taken place only for special ceremonies (Schapera 1933; Boonzaier *et al.* 1996; Sealy 2010). Faunal remains from sites such as OFD1, Khartoum and Pramberg provide good evidence that hunting and gathering was a very important means by which people obtained food. OFD 1 and Pramberg produced the remains of both wild and domestic animals (Maggs 1971; Brink *et al*. 1992), whereas the faunal assemblage at Khartoum consisted only of wild animals (Humphreys 1972; 1979). While the number of sites and sample sizes are too small to reconstruct the economy of these groups with certainty, they do provide some faunal data to compare with the historic and isotopic evidence.

There have been two recent biological anthropological studies of the Riet River skeletons. Irish et al. (2014) compared non-metric dental traits of the Riet River skeletons with a large sample of Later Stone Age humans from across South Africa, dating to the last 10000 years. Multivariate mean measure of divergence distance statistics indicated that Riet River did not diverge from other Khoesan groups, either geographically or temporally. This is contrary to the divergence shown by the Khoekhoe skeletons of Kakamas, which indicated outside genetic admixture (Irish et al. 2014). The observation is in agreement with the finding in this thesis, that the Riet River population had its own identity – it was a coherent community, not a mixed group of people with diverse origins.

A study on femoral length measurements of Riet River individuals has shown that they are of similar stature to Southern and Western Cape coast hunter-gatherers and herders (Cameron & Pfeiffer 2014). In addition to the femoral length measurements, the authors studied the cross-sectional geometric properties of the humerus and femur, to provide an idea on habitual behaviours. Similarly to the Irish *et al.* (2014) study, measurements indicated a statistically insignificant difference between the geographical groups. Cameron & Pfeiffer (2014:1) concluded that their results “indicate relative behavioural homogeneity among LSA foragers and herder-foragers from South Africa”. This work further supports the Khoesan biological identity of the Riet River community.

Conclusion

The aim of this study was to apply light stable carbon and nitrogen isotope analysis to 65 Riet River skeletons to contribute towards understanding the economy of the Riet River society, and to make comparisons with other, better-researched populations in the region. With the knowledge that the Riet River area was a frontier region that experienced unstable periods, a few questions were raised: What was the extent of outsider incorporation into the Riet River

communities? What was the relative importance of herding versus hunting and gathering within the local economy? Did trading relations with farming communities extend to the trading of cereal foods? In contributing towards further understanding the relationship between bone collagen and tooth enamel isotope chemistry, carbon isotope analysis was performed on the two tissues of each individual.

The poor correlation (R^2=0.24) between the $\delta^{13}C$ of enamel and bone for this study, compared to the stronger R^2=0.70 of Loftus & Sealy (2012) and R^2=0.88 from France & Owsley (2013) might be explained by the consumption of isotopically varied diets by the Riet River individuals. The distribution of $\delta^{13}C$ and $\delta^{15}N$ for this population, compared to a previous study (Lee-Thorp *et al.* 1993) indicates the consumption of a wide range of food resources, including both C_3 and C_4 based foods. Even though archaeological evidence is scarce (one fish bone from OFD1), it is now known that the Riet River people also exploited riverine resources, as they occupied the area along the Orange and Riet Rivers.

The individuals with the strongest C_4 signals (MMK 209, MMK 228, MMK 230, MMK 235, MMK 330, MMK 247, A 2799) overlap with the Iron Age group. This is important in elucidating the extent to which outsiders were being incorporated into Riet River societies. These individuals might have come from an Iron Age society, prior to being part of the Riet River community. Alternatively, there might have been trading of cultigens with these farming communities. The author does, however, realise the insignificance of food trading in the Riet River economy, as indicated by the lack of isotopic and archaeological support. The archaeological evidence from OFD1, Khartoum and Pramberg show the importance of hunting and gathering as a means of collecting food. The presence of a pair of conical copper 'extinguishers' with the female MMK 277, whose carbon and nitrogen signature fits with the rest of the population's, implies that the use of copper ornaments for personal adornment was a practice common to both males and females in the Riet River society.

Overall, the individuals in this study were part of a cohesive Riet River community, and relied to a large extent on hunting and gathering for food, probably supplemented by riverine resources. Their dental morphology is indistinguishable from that of pre-2000 BP San hunter-gatherers from other regions of South Africa, but it is different from that of approximately contemporaneous Khoekhoe herders from Kakamas (Irish *et al.* 2014). To the extent that dental morphology is a proxy for genetic relatedness, this observation is consistent with Burchell's description of nineteenth century communities in this area as 'Bushmen' who were trading in

stock, although Burchell's characterisation was based on the language/s that they spoke. The Riet River communities were very likely hunter-gatherers who had adopted stock-keeping. As such, they deserve more attention in debates about the introduction/adoption of herding among Khoesan communities in southern Africa.

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